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Argonne National Lab, IL Energy and Environmental Systems Div

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16. ABSTRACT

This guideline presents a methodology for the development of a control strategy conforming with the requirements for lead implementation plans found in Part 51 of Title 40 of the Code of Federal Regulations. The guidance presented herein illustrates, for a ficticious three-county example area, some of the quantitative and qualitative procedures used in developing the control strategy.

The guideline covers the following topics: development of baseline emission inventory and air quality data; projection and allocation of emissions; application of models and analysis of modeling results; and the testing, evaluation, and selection of available strategies.

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NOTE

Throughout the text, references to 40 CFR 51, the Federal Register regulations for the preparation, adoption, and submittal of implementation plans for the lead National Ambient Air Quality Standard (Ref. 18), are frequently given in abbreviated form in square brackets. For example, "[51.83(a)]" indicates that the material being presented in the text relates to the requirements of 40 CFR 51.83(a). The following index should facilitate the location of most of the information in the text related to those sections of 40 CFR 51 specific to lead.

Users of this guidance should also note that on July 16, 1979, EPA revised its recommended procedure for projecting automotive lead emissions found in Section 4.3 of the "Supplementary Guidelines for Lead Implementation Plans" (EPA-450/2-78-038). As a result of this revision, a major portion of the discussion pertaining to automotive lead emissions contained in this example control strategy guideline is no longer applicable. Specifically, the guidance found on pages 14-19 and 49-51 is based upon the old EPA estimating procedure. Copies of the revised Section 4.3 (Projecting Automotive Lead Emissions) may be obtained by contacting any EPA Regional Office, or by writing to the EPA Library Services (MD-35), Research Triangle Park, N.C. 27711, and requesting "Revised Section 4.3 - Projecting Automotive Lead Emissions," EPA-450/2-78-038a.

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1 INTRODUCTION

1.1 SCOPE AND OBJECTIVES

Current and possible future air quality problems must be analyzed in order to develop an air pollution control strategy designed to attain the National Ambient Air Quality Standard (NAAQS) for lead. Previous publications[1-15] by the EPA office of Air Quality Planning and Standards have been designed to give guidance in plan preparation. Reference 16 illustrates the application of some of the procedures described in these guidelines to the development of a control strategy emphasizing particulates. Recently, guidance[17] designed specifically to aid state, regional, and local air pollution control agencies in meeting the current regulatory requirements for lead implementation plans[18] has been published by EPA. The present work illustrates, for a ficticious three-county example area, some of the quantitative and qualitative procedures used in developing a control strategy for lead. Since it is not possible to cover all the different situations with which states must deal in strategy development, the scope of this example control strategy is necessarily limited. The general situation is handled by reference to appropriate guidance or by providing such guidance explicitly.

Development of a control strategy for lead follows lines parallel to those followed in developing a control strategy for particulates. Most of the guidance already available for particulates is applicable to lead and will not be repeated here; this work is an incremental document, particular to lead, which goes beyond the illustrations provided in Ref. 16. The major areas of difference between lead and particulate control strategy development relate to:

- The use of different emission factors for lead;
- The specified significant lead point sources to which dispersion models must be applied;
- The large fraction of lead emissions caused by highway vehicles and the consequent importance of this source category for lead; and
- The lead-specific methodology to be used in estimating projected highway vehicle lead emissions.

This work focuses on illustrating these and closely related areas where the development of a lead strategy might differ from the development of a particulate strategy. In general, the procedures and analyses with which states are already familiar, based on their experience with particulates, are equally applicable to lead.

This document does not address issues of intergovernmental cooperation, public hearings, or procedural and administrative matters related to plan submission and review. The emphasis is, rather, on the analytical procedures useful in developing and choosing a control strategy to meet the lead NAAQS.

It is not the purpose of this work to present new policy statements nor to issue new guidelines for analytical procedures. Rather, it is designed to illustrate existing guidelines and to clarify the application of current policy. This document is specifically directed at providing working-level state and local air pollution control engineers and planners with this guidance.

1.2 OVERVIEW

The analysis procedure reviewed here consists of the following steps:[16]

1. Develop baseline data bases,
2. Project future lead emissions,
3. Allocate emissions for modeling,
4. Estimate lead air quality by modeling,
5. Analyze the modeled results,
6. Develop and test alternative control strategies, and
7. Evaluate and select strategy for implementation based on relative effectiveness, ease of implementation, and, if desired, economic impacts.

These steps are discussed in Secs. 2-7 and are illustrated by application to the example area.

1.3 DESCRIPTION OF EXAMPLE AREA

In order to achieve a measure of realism in the example strategy, the data for the ficticious three-county example area have been based on Cook, DuPage, and Lake Counties, Illinois. This choice was made because a large amount of data had already been compiled for this area and because there are a large number of lead sources and heavy traffic flows in the area.

A large lake forms most of the eastern border of the example area, shown in Fig. 1.1. The topography is relatively flat throughout the area. The City of C, located in County C on the shore of the lake, is the major metropolitan and commercial center in the area. The shores of the lake have been kept relatively free of industrial development which has tended to concentrate in the southeastern part of County C, along navigable waterways to the west and south of the lake and around the satellite City W. Much of the area between cities C and W along the lake is residential and commercial in character. The area from the City of C to beyond the eastern half of County D contains many residential suburbs and light industrial parks.

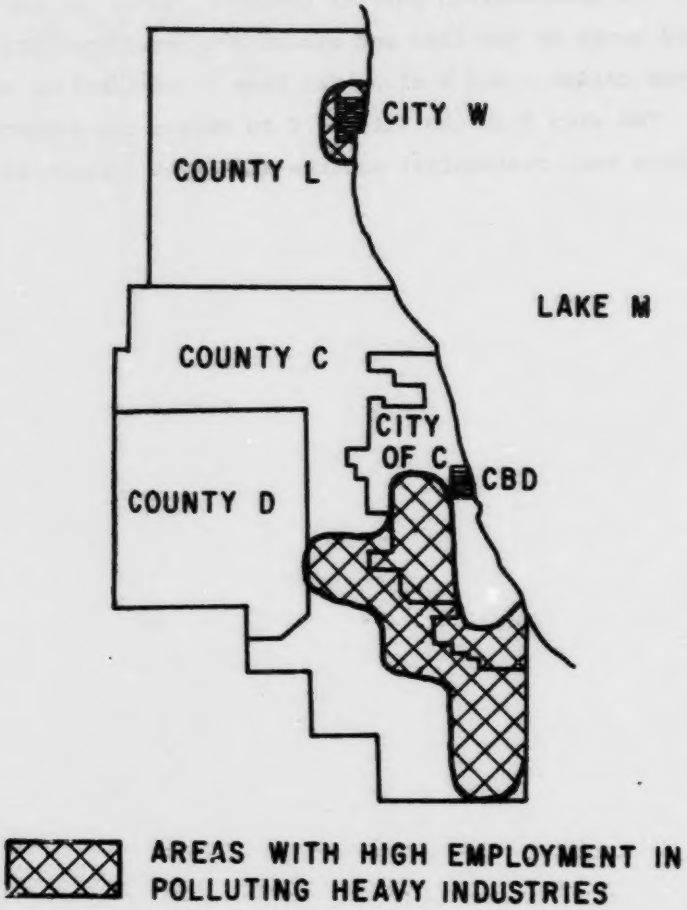

Fig. 1.1. Map of Example Area

2 DEVELOPMENT OF BASELINE DATA

The set of information required as a baseline for the development of a lead air quality analysis is made up of three parts: an emission inventory, meteorological data, and lead air quality data. The information should all be for the same base year and must correspond to the study area in question. In the example strategy, 1975 was chosen as the base year, because a full set of baseline data was available for that year.

2.1 EMISSION INVENTORY

The emission inventory forms the basis for making an assessment of air quality management problems. Detailed guidance in the development of an emission inventory has already been published.[7,13,16,19*] Specific guidance in the development of a lead emission inventory is also available.[17,24,25,29]

When developing the emission inventory, consideration should be given to temporal variations in source emissions where possible. Since the air quality standard for lead is based on a calendar quarter, source emissions by calendar quarter in the base year would be desirable. In this example strategy, lead emissions by a calendar quarter in the base year were not available. Emissions were assumed constant throughout the year.

The example area has its eastern border in common with another state. In developing the example strategy, emissions from the other state were not considered. In such a situation where an actual evaluation is being performed, states may need to consult the bordering state or states regarding their emission inventories and account for emission sources from the bordering states in the development of the control strategy.

2.1.1 Point Source Inventory

EPA regulations define a point source of lead as any stationary source whose actual emissions exceed 5 tons per year of lead or lead compounds measured as elemental lead [51.1(k)(2)].* All such point sources must be contained in the summary of the baseline lead emission inventory contained in the plan [51.81(a)]. In the vicinity of some of these point sources, called significant lead point sources, the plan must demonstrate attainment and maintenance through the use of an atmospheric dispersion model [51.80(a)(1) and 51.84(a),(b)]. It is convenient to assemble the data needed for modeling while the sources are being inventoried. The significant lead point sources are [51.80(a)(1)]:

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*Some of the information in Ref. 19 relating to area sources has been updated.

- Primary lead smelters,
- Secondary lead smelters,
- Primary copper smelters,
- Lead gasoline additive plants,
- Lead-acid storage battery manufacturing plants that produce 2,000 or more batteries per day, and
- Any other stationary source emitting 25 or more tons per year of lead.

The example point source lead emission inventory was based on a 1975 state particulate emission inventory. Although an existing particulate emission inventory provides an attractive basis for building the lead emission inventory, states should be aware that some stationary sources may be point sources of lead but not point sources of particulates. Thus, in compiling the list of lead point sources, states may need to consider sources not in the existing particulate point source inventory. The inventory used here was updated by including a number of additional point sources obtained from a local agency lead emission inventory.

The lead point source emission inventory should include fugitive emissions as well as stack emissions. Special attention should be given to the fugitive emissions as they may be the dominant lead source for some facilities. In the example area, fugitives were, in many instances, the more significant stationary source lead emission. Not many sources in the example area had annual emissions in excess of 5 tons of lead. Therefore, for demon-

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*[51.1(k)(2)] indicates that the material being discussed relates to 40 CFR 51.1(k)(2) of the Federal Register requirements for lead SIPs. See pp. *xi* and *xiii* for additional details and an index to pages discussing the requirements of 40 CRF 51 specific to lead.

stration purposes, stationary sources emitting more than 0.1 tons/yr of lead (fugitive plus stack emissions) were included in the point source inventory.

Determination of Point Source Lead Emissions

The determination of point source lead emissions should include both stack and fugitive emissions where fugitive emission determinations are possible. EPA indicates that it is preferable that the baseline lead emission inventory be based upon measured emissions.[18] Stack test procedures have been published[17] by EPA for determination of lead emissions. EPA has also published procedures for measurement of fugitive emissions from industrial sources[21,22,23] and states are not precluded from developing their own emission factors based on field studies using the published measurement procedures.[18] In this example strategy, point source stack and fugitive lead emissions were determined solely by the application of documented lead emission factors.

The first step in the construction of the lead point source emission inventory involves a compilation of lead emission factors (both stack and fugitive) for stationary source categories. EPA has published documents[24,25] that will be useful in this task. Emission factors keyed to specific Source Classification Codes (SCCs) are available in EPA's Hazardous and Trace Emissions System (HATREMS). A listing of these factors and associated default multipliers is given in Appendix C. The nonfugitive component of lead emissions from point sources calculated by using the HATREMS emission factors and the operating rates and control efficiency data in NEDS should be available to the state through EPA Regional Offices. Such an inventory may serve as a useful basis for the nonfugitive base-year emissions from a majority of point sources.

The example inventory presented here was developed primarily using the HATREMS factors as described below. At the time of this work, HATREMS could not be used exclusively for point source lead emissions factors, as the emission factor file did not contain fugitive lead emission factors or emission factors for all point source categories. The HATREMS factors were supplemented by factors based on References 24 and 25.

Having compiled a list of point source lead emission factors, the next step involves application of the emission factors to compute point source lead emissions. Reference 17 gives the following formula for the determination of lead point source emissions:

$$M_s = (1/2000) \times OR \times EF \times DM \times [1 - (W \times Y/100)/100] \qquad (2.1)$$

where:

M_s = stack lead emissions (tons/yr),

OR = Operating rate from NEDS or state emission inventory (SCC units/yr),

EF = Emission factor from HATREMS or other reference (lb/SCC unit),

DM = Default multiplier from HATREMS (dimensionless HATREMS units),

W = Particulate control efficiency from NEDS or state emission inventory (percent), and

Y = Control efficiency multiplier from HATREMS.*

Except for DM and Y, all these quantities are similar to the corresponding quantities for particulates. The quantity DM simply gives the lead content of the process material, for example, ppm by weight of lead in coal. HATREMS contains default values but the use of locally representative or source-specific values is recommended if available. Care should be taken to ensure that the units of DM are those appropriate to the corresponding emission factor EF. The quantity Y gives the percentage of the particulate control efficiency that can be applied to lead. Lacking any other data, Y = 100 was assumed in this work.

Illustrations from Example Area

The following example calculation illustrates the computation of the lead emissions from a grey iron foundry cupola (SCC 30400301) using Eq. 2.1.

---

*SCC (Source Classification Code) units are the operating rate units used in NEDS and HATREMS and are consistent with the emission factors used in these systems. For example, the SCC units for external combustion boilers are "tons burned" and the SCC units for primary lead smelters are "tons of concentrated ore." Appendix C of Ref. 26 (AP-42) lists the SCC units for each SCC.

According to the state inventory, the cupola produces 3,035 tons/yr of metal and the associated particulate control equipment is 95% efficient. Thus,

OR = 3035 tons metal/yr,

EF = 0.51 lb lead/ton metal from HATREMS,

DM = 1.00 from HATREMS,

W = 95 from state inventory, and

Y = 100 from HATREMS.

$$M_s = \frac{(3035)(0.51)[1-(95 \times 100/100)/100]}{2000}$$

or $M_s = 0.039$ tons lead/yr.

This source was too small to be included in the baseline point source inventory.

At the time of this work, HATREMS did not provide point source lead fugitive emission factors. Fugitive emission factors were obtained from Ref. 25 and lead fugitive emissions were calculated as above.

The following is an example calculation of fugitive lead emissions from a reverberatory furnace in a secondary lead smelting operation:

OR = 14,327 tons metal/year from state emission inventory,

EF_f = 1.73 lb fugitive lead/ton metal from Ref. 25,

DM = 1.00 (i.e., default multiplier not applicable),

W = 0 control efficiency (i.e., no control), and

Y = 100 so that

$$M_f = \frac{14,327 \times 1.73}{2000}$$

or $M_f = 12$ tons of fugitive lead/yr.

In the above calculation there was no control of fugitive emissions. Hence, W = 0. If, for instance, there were a 50% control efficiency on fugitive particulate emissions and if it were assumed or determined that the control efficiency was applicable to lead emissions as well, then the calculation would have had Y = 100 but W = 50.

Table 2.1 contains a listing of each inventoried point source along with the stack and fugitive lead emissions in the base year (1975). The locations of these point sources are indicated in Fig. 2.1.

2.1.2 Area Source Inventory

Sources not inventoried as points are inventoried as areas. For lead, these area sources are of three types:

1. Particulate point sources whose size does not qualify them for inclusion in the lead point source inventory,
2. The traditional area source categories such as residential fuel combustion and nonprocess fugitives, or
3. Highway vehicle sources including both specific highways (line sources) and nonspecifically located roads (area sources).

Determination of Nonhighway Source Lead Emissions

General. For particulate point sources not qualifying as lead point sources, the same procedures as described in Sec. 2.1.1, including Eq. 2.1 on p. 8, can be used to determine lead emissions. In reporting emissions in a format similar to that of Appendix D of 40 CFR 51 [51.81(a)], the emissions from these sources would be included as area sources. However, depending on the air quality model used and the level of detail of the analysis, it may be desirable to treat these sources as hybrid point/area sources. In this approach the sources would be inventoried as part of the area source emissions. The information regarding their locations would be retained, however, for use in allocating area source emissions as described in Sec. 4. This approach utilizes the maximum degree of spatial resolution available in the baseline data without requiring complete treatment and modeling of even small sources as points.

Standard methods, as described in Refs. 7 and 16, can be used to estimate emissions from the traditional area source emission categories. Emissions from these categories are generally estimated and projected at the county level and then allocated to subcounty areas for modeling purposes. The basic working equation is[17]

$$M = (1/2000) \times OR \times EF \times DM \qquad (2.2)$$

Table 2.1 Base-Year Point Source Lead Emissions[a]

Plant	Source Classification Code (SCC)	Source Description	Lead Emissions (tons/yr)		
			Stack	Fugitive	Total
A	50100101	Municipal Incinerator	29.76	0.02	29.78
B	30400303	Gray Iron-Electric Inductions	9.02	9.02	18.04
C	30300802	Iron-Blast Furnace	.87	0.02	.89
	10200402	Boiler-Residual Oil	.03	b	.03
	30300901	Steel-Open Hearth	10.57	3.85	14.42
					15.34
D	50100101	Municipal Incinerator	0.83	neg	0.83
	50100101	" "	0.83	neg	0.83
	50100101	" "	0.83	neg	0.83
	50100101	" "	0.83	neg	0.83
					3.32
E	30400303	Gray Iron-Electric Induction	1.41	1.41	2.82
F	30902099	Can Making	1.44	b	1.44
G	30400401	Secondary Lead-Smelting	1.95	1.20	3.15
H	30300801	Iron-Blast Furnace	.45	neg	.45
	30300801	" " "	.74	neg	.74
					1.19
I	30400402	Secondary Lead-Reverberatory Furnace	.73	12.39	13.12
	30400401	Secondary Lead-Smelting	.16	.80	.96
					14.08
J	10100201	Boiler-Bituminous Coal	.06	b	.06
	10100201	" " "	.23	b	.23
	10100203	" " "	.49	b	.49
	10100202	" " "	.19	b	.19
	10100202	" " "	.08	b	.08
					1.05
K	30300903	Steel-BOF	.29	2.94	3.23
	30300802	Iron-Blast Furnace	.06	.27	.33
					3.56
L	10100203	Boiler-Bituminous Coal	.34	b	.34
	10100201	" " "	.05	b	.05
					.39
M	30400402	Secondary Lead-Reverberatory Furnace	.80	b	.80
N	30400402	" " " "	.67	b	.67

[a] Includes all lead sources in plants whose total emissions exceeded 0.1 tons lead/yr and all plants on the significant source list.

[b] No fugitive emission factor available.

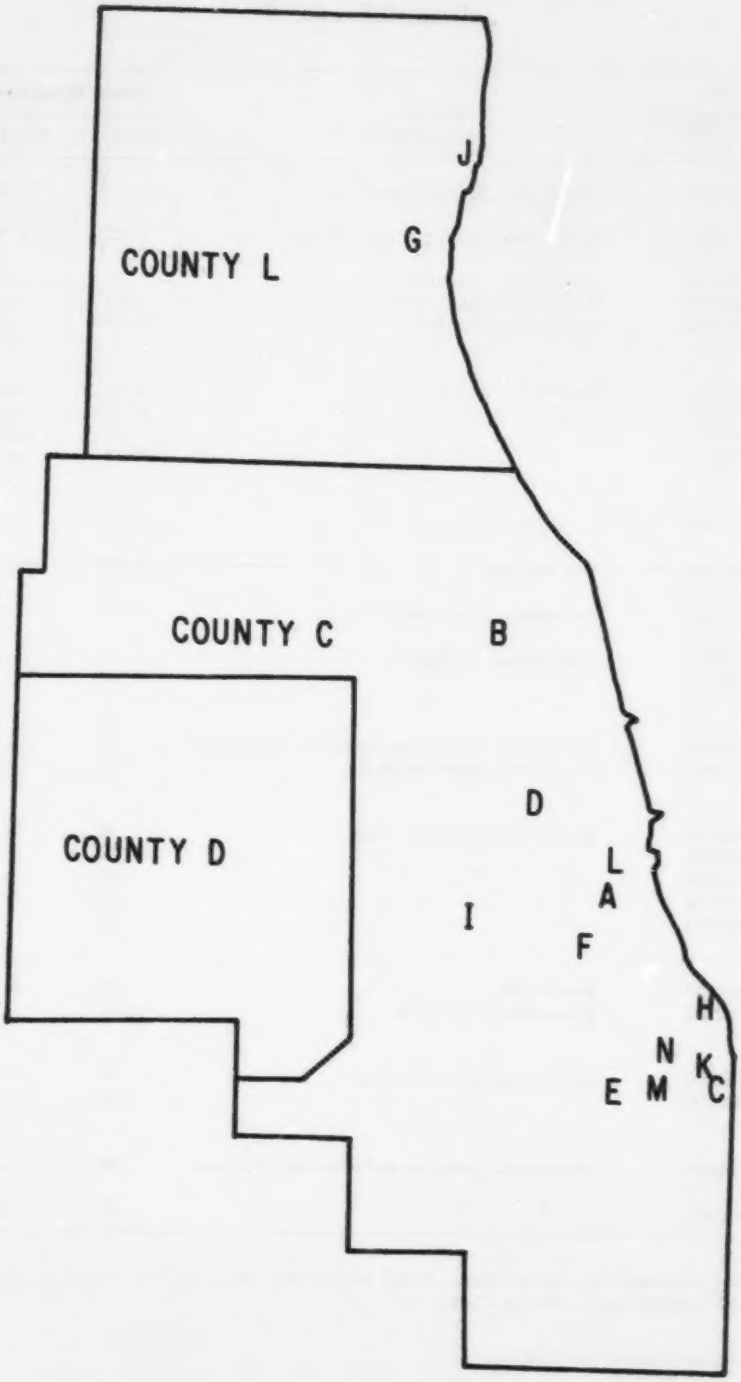

Fig. 2.1. Location of Lead Point Sources in Example Area

where the various factors have the same meanings as in Eq. 2.1 and it has been assumed that emissions are uncontrolled. HATREMS provides the most comprehensive source of emission factors and default multipliers for area sources. Reference 24 may also be useful in determining default multipliers. As for point sources, values of the default multipliers based on local data are preferable to the national values supplied by HATREMS.

Reentrained road dust is one category that might not have received close attention in previous particulate inventories. Reference 29 provides specific recommendations for reentrained road dust lead emission factors under steady state conditions. Use of these emission factors requires that VMTs be known. The factor is 0.03 grams/vehicle-mile in 1975-76 and is expected to be reduced by approximately a factor of three to under 0.01 grams/vehicle-mile by 1980. For projection to 1982 and beyond, it should be noted that this reduction is almost the same as the reduction in the probable pooled average lead content of gasoline (from ∿ 1.5 to 0.5 grams/gal) projected in Ref. 17. Further proportional reductions in the reentrainment emission factor should occur after 1982 as the lead content of gasoline is decreased further.

Illustrations from Example Area. Since the calculation of point source emissions has already been illustrated, no further example calculations are presented here for the particulate point sources not included in the lead point source inventory.

The following is an example of how Eq. 2.2 and the HATREMS area source lead emission factors were used to calculate traditional area source lead emissions for commercial and institutional burning of distillate fuel oil. As shown in the baseline data in Appendix A, 1975 distillate fuel oil consumption in County C amounted to 140,160 SCC units/yr. Thus,

OR = 140,160 SCC units/yr,
EF = .004 lb lead/SCC unit from HATREMS, and
DM = .100 from HATREMS.

Using Eq. 2.2

$$M = (1/2000) \times (140{,}160) \times (.004) \times (.100)$$

or

$$M = .028 \text{ tons lead/yr.}$$

The calculation of reentrained lead emissions is also relatively straightforward, as shown by the following example calculation. From Appendix A, the arterial VMT in 1975 in County D was 9,429,900 vehicle-miles/day. On a yearly basis, emissions from reentrained lead dust, Q_{rld}, would be given approximately by

$$Q_{rld}^{75} = 9{,}429{,}900\ (\text{VMT/day}) \times 365\ (\text{day/yr}) \times 0.03\ (\text{g/VMT}) \times (1/907{,}200)(\text{tons/g})$$

$$= 114 \text{ tons/yr of lead from reentrained road dust on arterial roads.}$$

The emission factor 0.03 g/VMT comes from Ref. 29. Similar calculations can be applied to the areterial VMTs for other counties and also to each freeway link in the baseline traffic data. As noted above, when emissions are projected beyond 1975, the emission factor must be reduced to reflect the expected reduction in the lead content of gasoline.

Determination of Highway Source Lead Emissions

This example plan used the values listed in the Supplementary Guideline (Ref. 17) for the parameters needed to calculate lead emissions from highway sources. Other values may be developed. It is suggested that states check with the EPA Regional Office to determine whether any updates of the parameter values given in Ref. 17 have been issued.

General. There is more than one way that a highway source emission inventory can be constructed. Alternative procedures have been documented by EPA.[7,16] However, the supplementary lead guidline[17] recommends a method based on VMT data and this method should be used whenever possible. Lead emissions from arterials and freeways can be determined using the formulas, data tables, and graphs contained in this reference. The basic working equation is:

$$e_{n,s} = (a_s \times Pb_n \times T)/f_{n,s} \tag{2.3}$$

where

$e_{n,s}$ = emission rate for calendar year n and speed s (g/road mile-day),

a_s = percentage of lead burned that is exhausted (expressed as a decimal),

Pb_n = probable pooled average lead content of gasoline in year n (g/gal),

T = average daily traffic (vehicles/day),

$f_{n,s}$ = average fleet fuel economy for calendar year n and speed s (vehicle - road mile/gal).

This form of the equation is satisfactory for calculating emission densities. However, for most emission inventory work, emission rates are desired. By multiplying each side by the number of road miles traveled, Equation 2.3 can be modified slightly to give the following from which uses VMT data:

$$E_{n,s} = (a_s \times Pb_n \times VMT_n)/f_{n,s} \tag{2.4}$$

where

$E_{n,s}$ = emission rate for calendar year n and speed s (g/day), and

VMT_n = average daily vehicle miles traveled in year n (VMT/day).

In both Eqs. 2.3 and 2.4, the factor a_s depends on vehicle speed. EPA has recommended, however, that Ref. 17 be amended regarding the percentage of lead burned that is exhausted for stop-and-go traffic (i.e., variable driving conditions).[42] For such conditions (e.g., on most arterial roadways), a value of $a_s = 0.70$ has been recommended for use rather than a value calculated from the Fig. 4.3-1 in Ref. 17. This value (0.70) will be used regardless of the average route speed. For freeways, steady-state conditions on particular links, and acceleration lanes, the speed or acceleration-dependent values of a_s in Ref. 17 would still be used. Thus, there will be two equations corresponding to Eq. 2.4:

$$\left.\begin{array}{ll} E_{n,s} = (a_s \times Pb_n \times VMT_n)/f_{n,s} & \text{(steady-state conditions on individual roadways or acceleration lanes)} \\ \text{and} & \\ E_{n,s} = (0.70 \times Pb_n \times VMT_n)/f_{n,s} & \text{(stop-and-go traffic or long-term, varied driving conditions).} \end{array}\right\} \quad (2.5)$$

A similar set of equations would correspond to Eq. 2.3.

These equations are basically the same for all vehicle types. However, for heavy-duty gasoline-powered trucks, the factor $f_{n,s}$ is assumed to be independent of both year and speed.[17] Thus, average daily traffic or VMT data should be available for heavy-duty gasoline-powered trucks as a separate item in the basic data set. Light-duty truck and automotive emissions are calculated in the same way, requiring a calculation of $f_{n,s}$ for different years and speeds (for freeways). Motorcycles and diesel-powered vehicles may be assumed negligible lead emitters.[17]

In reporting emissions in a format similar to that of Appendix D of 40 CFR 51, emissions from both individual freeway links and arterials can be included as area sources. (The format might also be altered as was done here to include the freeway emissions as a separate line item). However, it may be desirable to retain the locational information for those links for which individual emissions rates have been calculated, thus inventorying them as line sources. Emissions from such links could then be allocated to the source grid for modeling with more accuracy than if they had been aggregated with other highway emissions and allocated by using an allocation parameter. Such a procedure was followed in this example strategy for illustrative purposes but is not necessarily required under the current regulations. Some states may not have access to transportation data in a format suitable for developing such an inventory. Even if data is available, states may find that the increase in spatial resolution of highway lead emissions is not warranted in their areas.

Illustrations from Example Area. VMT data by vehicle type were disaggregated from the county-level data presented in Appendix A using figures on percentage VMT by vehicle type obtained from transportation planning agencies. This disaggregation was necessary because the methodology for calculating emissions depends on vehicle type.

The following is an example of how arterial lead emissions from heavy-duty gasoline-powered trucks were calculated for County C in the three-county area. Since the available traffic data were presented in terms of VMT, the form of Eq. 2.5 with $a_s = 0.70$ appropriate to the varied driving conditions characterizing arterials was used. To use the equation, Pb_{75}, VMT_{75}, and $f_{75,s}$ must also be found. Pb_{75} can be found from Table 4.3-8 in Ref. 17; $Pb_{75} = 1.9$ gram/gal. The required VMT figure was disaggregated from the data presented in Appendix A, as noted above. It was found that $VMT_{75} =$ 1,055,690 vehicle-miles/day for heavy-duty trucks in County C. Finally,

$f_{75,s}$ = 5.7 vehicle-miles/gal as noted in Ref. 17 for this source category. Then,

E_{75} (County C; heavy-duty gasoline-powered trucks)

$= 0.70 \times 1.9$ (gram/gal) $\times$ 1,055,690 (vehicle-miles/day)/ 5.7 (vehicle-miles/gal)

= 246,330 grams lead/day

= 99 tons lead/yr.

The example calculation demonstrates how lead emissions were calculated for heavy-duty gasoline-powered trucks, using VMT data instead of vehicles/day. The calculation of lead emissions from passenger and light-duty gasoline-powered vehicles is slightly more complicated although the VMT would be handled in exactly the same manner. The difference in the calculation for heavy-duty trucks and the calculation for light-duty trucks and automobiles is in the factor $f_{n,s}$ and the value of Pb_n. The calculation of the term $f_{n,s}$ for passenger and light-duty vehicles is rather lengthy and is fully explained and illustrated in the EPA lead guideline document (Ref. 17). Values of Pb_n for passenger and light-duty vehicles are taken from Table 4.3-1 in Ref. 17 rather than from Table 4.3-8.

Freeways in the example area were approximated by a series of straight line segments, or links, on a transportation map. The VMT for each link was computed and the UTM coordinates of the end points of each link determined for subsequent allocation. This level of detail is not required and may not be warranted in particular areas. Lead emissions were calculated for each link based on VMTs and vehicle type distribution, as discussed above for arterials. In calculating emissions from freeways, account must be taken of the speed dependence of the factor a_s in Eq. 2.5. The value of a_s can be determined as a function of vehicle cruise speed using Fig. 4.3-1 in the EPA guideline document (Ref. 17). Where a link was not entirely within the example area, the lead emissions applicable to the area were determined as that percent of the link which was in the example area. For instance, if the total link measured 4" on the transportation map and 1" was within the example area, then 25% of the total link lead emissions would be attributed to the portion of the link within the example area. The freeway links for which individual emission rates were calculated are shown in Fig. 2.2. Since

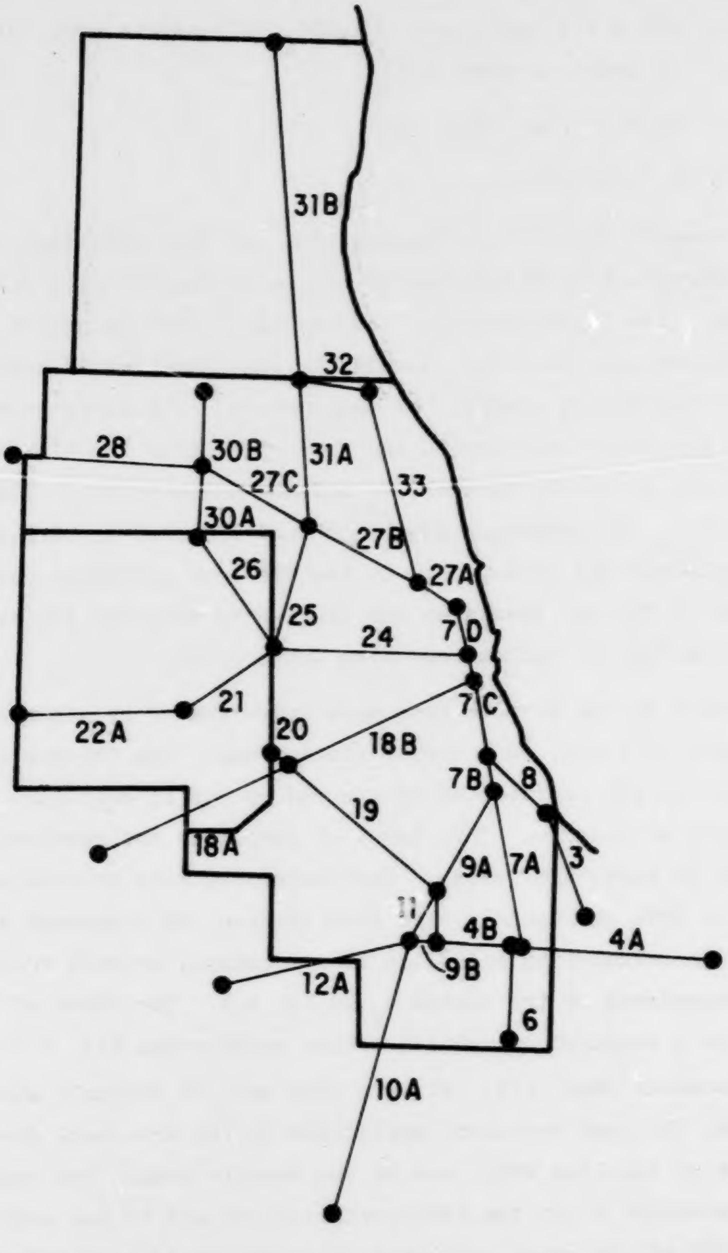

Fig. 2.2. Freeway Links for Example Area Line Sources

the calculation is rather lengthy and has been described in detail in Ref. 17, no example calculations are presented here.

2.1.3 Example Area Lead Emission Inventory

Using the methods presented and illustrated above, an emission inventory was developed for the example area. Table 2.2 summarizes the base-year emission inventory for the entire three-county example area in the National Emissions Report (NER) format specified in Ref. 7. This format is similar to that specified in Appendix D of 40 CFR 51. Both Ref. 7 and Appendix D specify reporting emissions for each county separately and this specification should be followed in plan development and submission. However, for illustrative purposes, only regional totals have been presented here. The format has been modified slightly to reflect better the emissions of lead. For example, emissions from freeways (line sources) and arterials (area sources) have been listed separately to give greater detail for the dominant source category. This additional detail is not required by the current SIP regulations. Table 2.2 shows the importance of vehicular emissions in the example area. Land vehicles contribute almost 78% of the total lead emissions directly and are responsible for another 15% through dust from reentrainment and unpaved roads. Lead point sources contribute only 2.1% of the total.

2.2 AIR QUALITY DATA

2.2.1 SIP Requirements

EPA regulations require states to submit a summary of all lead air quality data measured since January 1, 1974 [51.82(a)]. In addition, all lead air quality data measured since January 1, 1974 must be submitted to the appropriate Regional Office with the SIP, but not as part of the SIP [51.86(c)]. Data reporting procedures and formats have also been published by EPA.[17,27] States are required [51.82(a)] to evaluate lead air quality data for

- Reliability,
- Suitability for calibrating dispersion models, and
- Representativeness.

Table 2.2 Example Area Baseline Lead Emissions (1975)[a]

YEAR 1975

SOURCE				EMISSIONS, TONS PER YEAR				
				LEAD				
FUEL COMBUSTION: EXTERNAL	RESIDENTIAL FUEL (AREA)	ANTHRACITE COAL		.00021				
		BITUMINOUS COAL		3.17				
		DISTILLATE OIL		.00063				
		RESIDUAL OIL		--				
		NATURAL GAS		--				
		WOOD		--				
		TOTAL		3.1708				
	ELECTRIC GENERATION ~~(POINT)~~	ANTHRACITE COAL						
		BITUMINOUS COAL - Area		.068				
		LIGNITE - Area		.0004				
		RESIDUAL OIL - Area		.1143				
		DISTILLATE OIL - Area		.00049				
		NATURAL GAS						
		PROCESS GAS						
		~~COKE~~ Bit. Coal-Point		1.44				
		SOLID WASTE/COAL						
		TOTAL	Area	0.1832				
			Point	1.44				
	INDUSTRIAL FUEL	ANTHRACITE COAL	AREA	.0019				
			POINT					
		BITUMINOUS COAL	AREA	5.198				
			POINT					
		LIGNITE - Area	~~POINT~~	.0074				
		RESIDUAL OIL	AREA	1.132				
			POINT	.0319				
		DISTILLATE OIL	AREA	.0360				
			POINT					
		NATURAL GAS	AREA	--				
			POINT					
		PROCESS GAS	AREA	--				
			POINT					
		COKE	POINT	--				
		WOOD	AREA	--				
			POINT					
		LIQUID PETROL GAS	POINT	--				
		BAGASSE	POINT	--				
		OTHER	POINT	--				
		TOTAL	AREA	6.3753				
			POINT	.0319				

Table 2.2 (Cont'd)

SOURCE				LEAD				
FUEL COMBUSTION: EXTERNAL (CONTINUED)	COMMERCIAL-INSTITUTIONAL FUEL	ANTHRACITE COAL	AREA	--				
			POINT					
		BITUMINOUS COAL	AREA	.1546				
			POINT					
		LIGNITE	POINT					
		RESIDUAL OIL	AREA	.5088				
			POINT					
		DISTILLATE OIL	AREA	.0323				
			POINT					
		NATURAL GAS	AREA	--				
			POINT					
		WOOD	AREA	--				
			POINT					
		LIQUID PETROL GAS	POINT	--				
		OTHER	POINT	--				
		TOTAL	AREA	.6957				
			POINT	--				
	OTHER		POINT					
	TOTAL EXTERNAL COMBUSTION		AREA	10.425				
			POINT	1.4719				
FUEL COMBUSTION: INTERNAL	ELECTRIC GENERATION	DISTILLATE OIL						
		NATURAL GAS						
		DIESEL						
		OTHER						
		TOTAL						
	INDUSTRIAL FUEL	DISTILLATE OIL						
		NATURAL GAS						
		GASOLINE						
		DIESEL						
		OTHER						
		TOTAL						
	COMMERCIAL-INSTITUTIONAL FUEL	DIESEL						
		TOTAL						
	ENGINE TESTING	AIRCRAFT						
	TOTAL INTERNAL COMBUSTION			--				
TOTAL FUEL COMBUSTION		AREA		10.425				
		POINT		1.4719				

Table 2.2 (Cont'd)

SOURCE				LEAD				
INDUSTRIAL PROCESS (POINT)	CHEMICAL MANUFACTURING							
	FOOD/AGRICULTURE							
	PRIMARY METAL			--				
	SECONDARY METALS			59.63				
	MINERAL PRODUCTS							
	PETROLEUM INDUSTRY							
	WOOD PRODUCTS							
	PROCESS EVAPORATION							
	METAL FABRICATION			1.44				
	LEATHER PRODUCTS							
	TEXTILE MANUFACTURING							
	INPROCESS FUEL							
	~~OTHER/NOT CLASSIFIED~~ Secondary Metals-Area			4.738				
	TOTAL Area/Point			4.738/61.07				
SOLID WASTE DISPOSAL	GOVERNMENT (POINT)	MUNIC. INCIN.		33.14				
		OPEN BURNING						
		OTHER						
		TOTAL		33.14				
	RESIDENTIAL (AREA)	ON-SITE INCIN.		283.82				
		OPEN BURNING		--				
		TOTAL		283.82				
	COMMERCIAL-INSTITUTIONAL	ON-SITE INCINERATION	AREA	--				
			POINT					
		OPEN BURNING	AREA	--				
			POINT					
		APARTMENT	POINT	--				
		OTHER	AREA	--				
			POINT					
		TOTAL	AREA	--				
			POINT					
	INDUSTRIAL	ON-SITE INCINERATION	AREA	--				
			POINT					
		OPEN BURNING	AREA	--				
			POINT					
		AUTO BODY INCIN.	POINT	--				
		UIHER	POINT	--				
		TOTAL	AREA					
			POINT	--				
	TOTAL SOLID WASTE DISPOSAL		AREA	283.82				
			POINT	33.14				

Table 2.2 (Cont'd)

SOURCE				LEAD				
TRANSPORTATION (AREA)	LAND VEHICLES	GASOLINE ARTERIAL	LIGHT DUTY	2715.				
			HEAVY DUTY	129.26				
			OFF HIGHWAY	65.709				
			TOTAL	2910.				
		~~DIESEL~~	HEAVY DUTY	10.093				
		GASOLINE FREEWAY	LIGHT DUTY	469.34				
			RAIL					
			TOTAL	479.433				
	AIRCRAFT	MILITARY						
		CIVIL						
		COMMERCIAL						
		TOTAL						
	VESSELS	BITUMINOUS COAL						
		DIESEL FUEL						
		RESIDUAL OIL						
		GASOLINE						
		TOTAL						
	GAS HANDLING EVAPORATION LOSS							
	TOTAL TRANSPORTATION			3389.				

Table 2.2 (Cont'd)

SOURCE			LEAD				
MISCELLANEOUS (AREA)	SOLVENT EVAPORATION	INDUSTRIAL SOURCES (AREA)					
		DRY CLEANING					
	FIRES	STRUCTURAL					
		FROST CONTROL					
		SLASH BURNING					
		WILD FOREST					
		AGRICULTURAL					
	DUST CAUSED BY HUMAN AGITATION OF THE AIR	UNPAVED ROADS	.0256				
		UNPAVED AIRSTRIPS	--				
		PAVED ROADS	667				
		MINERAL PROCESSING					
		TILLING ACTIVITIES	.00328				
		LOADING CRUSHED ROCK, SAND, GRAVEL	--				
		CONSTRUCTION	--				
	AIRBORNE DUST CAUSED BY NATURAL WINDS	STORAGE PILES					
		TILLED LAND					
		UNTILLED LAND					
GRAND TOTAL	AREA		4355.				
	POINT		95.68				

[a] The standard NER format has been altered where necessary to fit the requirements of a lead inventory.

EPA has promulgated a reference method (atomic absorption spectrophotometry) for the determination of ambient lead concentrations.[20] If a state analyzes previously collected filters from high volume samplers for lead, EPA will accept data based on analysis by x-ray fluorescence and has stipulated that other analysis methods may also qualify if approved by the Regional Administrator [51.82(b)]. EPA has also proposed other equivalent sampling procedures. (See Ref. 28 for the detailed proposal.) States which have not used the promulgated procedures to collect and analyze base year air quality data should consult with their EPA Regional Office as to the appropriateness of using such data for a lead strategy analysis.

2.2.2 Example Area Lead Air Quality Data

Lead air quality data for the example area were obtained from three different sources: a municipal agency, a county agency, and the EPA Regional Office. The UTM coordinates of the sampling stations were provided along with a description of the sampling and analysis procedures. Air quality data from the EPA Regional Office were obtained from EPA's Storage and Retrieval of Aerometric Data (SAROAD) system. In all cases, lead sampling was indicated as being done by the high volume air sampling procedure utilized for sampling total suspended particulate matter. The sample analysis procedure was EPA's promulgated reference method.

Data Reliability

An in-depth determination of data reliability was beyond the scope of this work. No inspection of sampling sites in the example area or sample analysis laboratories was performed. Discussion with the cognizant agencies indicated, however, that there was substantial compliance with EPA sampling and analysis procedures and that appropriate quality assurance measures were taken. States are, however, expected to report deviations from promulgated sampling and analysis procedures to the EPA Regional Office.

Suitability for Calibrating Dispersion Model

A limited discussion of the suitability of air quality data for calibrating dispersion models is given in Ref. 16. When possible, the air quality data must be from the same base year as the emission inventory and must also be for the same averaging time as the standard. The lead ambient air quality standard is 1.5 $\mu g/m^3$ arithmetic mean averaged over a calendar quarter. Monthly arithmetic mean air quality data were received from the local agency and averaged to give calendar quarter arithmetic means.

The spatial distribution of sites with air quality data is also important. Since states are required to calculate and locate, using dispersion models, maximum lead concentrations in the vicinity of specified significant point sources, it is desirable to have measured lead air quality data in the vicinity of such sources. Measured air quality representative of significant vehicular activity such as major freeways which have high VMT is also desirable. States, of course, will have to rely on data from their existing monitoring network. The lack of suitable lead sampling coverage in areas determined to be potential hot spots as a result of lead emission analysis frequently cannot be remedied unless previously collected high-volume filters can be analyzed for lead.

Representativeness of Lead Air Quality Data

The measured lead air quality data should be representative of receptor exposure. Measures of representativeness include:

- Height of the sampling station, and
- Placement of the sampling station with respect to both receptors and sources.

Guidance is available in Reference 17 to aid in evaluating monitoring site location. EPA is also developing guidance describing network design and siting criteria that will eventually appear in regulatory form. As currently required, stations used for ambient lead monitoring should include at least one roadway site and one neighborhood site [51.17(b)]. Roadway sites are expected to show the highest ambient concentrations. Neighborhood sites in neighborhoods with poor lead air quality would give a picture of population exposure in high population density areas. Reference 17 also provides special treatment for the location of monitors at street canyon sites in downtown areas. Street canyon sites usually combine high traffic and high population density. Additional details are discussed in Ref. 17.

The sites of the lead sampling stations in the example area were not inspected. Conversations with local agencies indicated that many of the sampling stations are located on the roofs of schools. Lead sampling station data obtained from the Regional EPA Office were in SAROAD format and the elevations of the stations above ground level were specified. Of the two SAROAD sampling stations, one station was 23 feet (7 meters) and the other 105 ft. (32 meters) above ground level. Reference 17 specifies that a lead sampler be placed at a height no greater than 5 meters above ground level. If height criteria are exceeded, the air quality values near ground level can be expected to be higher than the measured values. Although a 5 meter maximum lead sampler height has been proposed, it is not applicable to base-year sampling monitors because all the base-year data is needed for SIP development. The height specification is indicative, however, of a determination by EPA regarding the collection of representative lead air quality data as well as for the establishment of new sampling sites.

Although many of the rooftop sites probably exceed the proposed height criterion, data from all these sites and the data from both SAROAD sites were included in the baseline data set. States should consider the height of their base-year lead sampling stations, especially for stations in potential hot spots and, in cases where doubt exists, discuss with the EPA Regional Office the possibility of poor representation of lead air quality as a result of sampling station height.

Even though the height criterion was not applied in this example strategy, not all lead sampling station data were used. A check of the sampling station location by plotting the station UTM coordinates revealed that some stations had erroneous UTM coordinates. Where UTM coordinate corrections could not be made in a timely manner, the air quality data were not used.

In the example area, lead air quality data were available from 39 verified sampling stations. Unfortunately 38 of these stations were in County C. One sampling station was in County L, and there were no base-year lead sampling stations in County D. Figure 2.3 shows the location of each lead sampling station in the example area. This figure clearly illustrates the lack of spatial coverage.

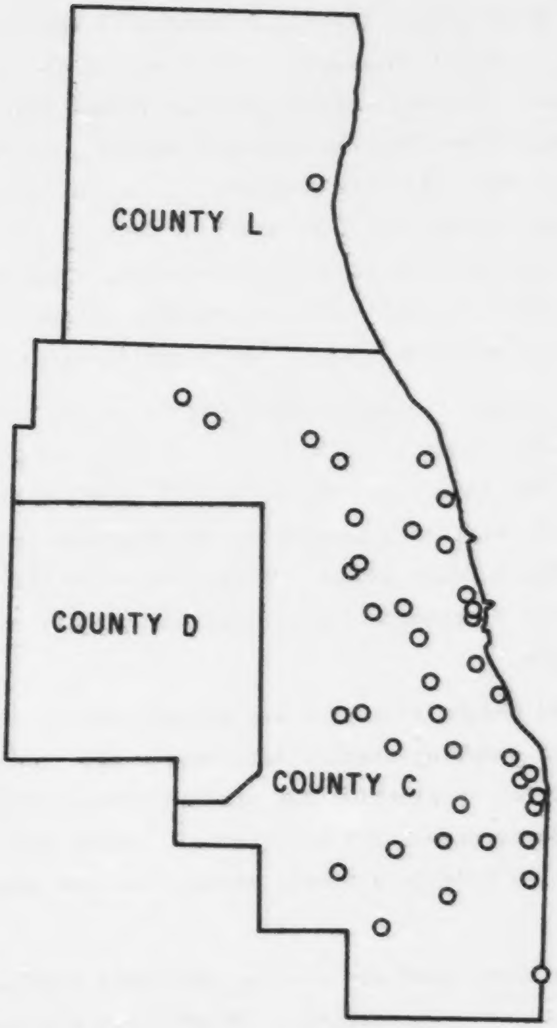

Fig. 2.3. Locations with Available Lead Ambient Air Quality Data

Determination of Background Lead Concentration

A discussion of background lead concentrations can be found in Ref. 17. EPA recommends that states assume a background equivalent to concentrations of airborne lead in a "representative nonurban area that is not significantly influenced by stationary or mobile lead sources." After consultation with EPA, measured nonurban lead air quality data from outside the example area were evaluated to estimate a background concentration. Since the range of the data was only 0.08 $\mu g/m^3$, it was decided to use an arithematic average of all the outlying nonurban data as a reasonable approximation to background lead air quality. The background ambient lead air quality level was determined to be 0.15 $\mu g/m^3$. States may wish to consult with the EPA Regional Office regarding the choice of a background ambient concentration for lead in cases where doubt exists concerning validity of a determination or where suitable data is unavailable.

Selection of Calendar-Quarter Base-Year Lead Air Quality Data

For lead, a calendar quarter of air quality data must be chosen as the air quality baseline for strategy development and modeling rather than a full year as is the case for particulates. Little specific guidance is available as to how to choose the most appropriate quarterly lead air quality data. For the example strategy, the choice was made based on inspection of the base year measured data. There were no gross violations of the lead standard measured in 1975 in the example area. The second calendar quarter data was chosen as the baseline quarter because it contained the highest average lead concentration (1.600 $\mu g/m^3$) among all the sampling stations as well as the greatest number of stations that measured lead concentrations greater than 1.0 $\mu g/m^3$. Table 2.3 lists the 1975 air quality data for lead by calendar quarter for the example area.

In general, the considerations involved in selecting the baseline quarterly data should include, but not necessarily be limited to:

- The quarter in which the maximum quarterly average lead concentration was observed;
- The existence of particularly large violations of the standard in one quarter, say by a factor of more than about two or three; and

Table 2.3 Base-Year (1975) Lead Air Quality Data

Station	Ambient Lead Concentration ($\mu g/m^3$)[a]			
	Calendar Quarter			
	January-March	April-June	July-September	October-December
1	.340	.501	.433	.203
2	.709	1.089	.822	.701
3	.540	.519	.562	.477
4	.700	.859	.959	.666
5	.826	1.093	1.250	.700
6	1.075	1.206	1.287	.679
7	.672	.784	.865	.486
8	.470	.617	.566	.310
9	.695	.769	.777	.536
10	.521	.669	.379	.298
11	.543	.774	.884	.467
12	.601	.627	.685	.412
13	.360	.563	.487	.345
14	.577	.518	.401	.256
15	.436	.729	1.059	.507
16	.625	.875	1.007	.853
17	.833	1.100	.367	-
18	.800	.867	-	.667
19	1.067	-	-	.733
20	1.200	1.000	.833	.633
21	1.133	1.233	.700	.700
22	-	-	1.367	1.067
23	.867	.933	-	.933
24	.733	1.067	.500	.800
25	.633	.733	.333	.467
26	.733	.733	.700	.767
27	.767	.700	.633	.533
28	.867	.667	.500	.533
29	.667	.967	.667	.533
30	-	.500	.433	.367
31	.633	.367	.667	.400
32	.667	.733	.633	.567
33	-	.700	.600	.300
34	.733	.400	.300	.400
35	.867	1.167	.967	-
36	.767	1.600	.733	.867
37	.400	.367	.667	.800
38	.667	.700	-	.467
39	.767	.633	.333	.900

[a] Based on average of monthly means obtained from local agencies and SAROAD.

- The occurrence of the largest number of standard violations and/or the largest number of exceedences of some other relatively high concentration (such as the 1.0 μg/m^3 value used in this example strategy).

Choice of the quarter in which the maximum quarterly average was observed is consistent with current EPA policy for other pollutants. The other two considerations might thus assume less weight in choosing a baseline quarter and serve primarily to confirm the choice based on the observed maximum. In the abscence of specific guidelines, consultation with the EPA Regional Office is advised in cases of doubt.

2.3 METEOROLOGICAL DATA

A discussion of meteorological data in general can be found in Ref. 16. References 12 and 31 discuss the meteorological data requirements of dispersion models; Reference 30 discusses those of the various modified rollback models. In general, the development of baseline meteorological data for lead is subject to the same considerations as the development of such data for particulates. The major difference is that quarterly rather than annual data is appropriate for lead.

Selection of Baseline Quarterly Meteorological Data

Once the baseline quarterly air quality data have been selected, the baseline meteorological data must correspond to the same year and quarter to retain consistency between the two data sets. Use of data from different calendar quarters would not be appropriate.

Selection of Quarterly Meteorological Data for Air Quality Projections

Little guidance exists concerning the choice of worst case meteorological data for projection purposes. Reference 16 discusses some of the important considerations. If time and resources permit, a sensitivity analysis comparing modeled air quality concentrations for meteorological conditions representing data from several quarters while keeping the emissions inventory constant may aid in determining worst case meteorology. No more than five years of data would need to be examined to make a reasonable determination.[31] However, it is unlikely that this amount of effort will be feasible in many situations. Also, data may not be available for such a long time span. Reference 31 provides some guidance in attempting to determine worst case meteorology for estimating future pollutant concentrations. In any event, an air pollution meteorologist should be consulted to aid in the determination of the worst case conditions to be used in estimating future lead air quality.

One year (1975) of data was readily available for the example area in the form of monthly (STAR) stability wind roses obtained from the National Climatic Center (NCC), Federal Building, Asheville, North Carolina 28801. As discussed above, the second quarter of 1975 appeared to represent a worst case from an air quality perspective. A quarterly average stability wind rose for the second calendar quarter was obtained by averaging the monthly wind roses for April, May, and June. This averaging procedure will probably be necessary if NCC data is used because calendar quarter stability wind roses are apparently unavailable; only seasonal quarter (for example March, April, May) wind roses appear to be available. Users should contact NCC if questions arise concerning STAR summaries.

3 PROJECTING FUTURE EMISSIONS

Current regulations [51.81(b)] require that projections of lead emissions be made for at least three years beyond the date by which EPA must approve or disapprove the lead SIP (five years if an extension under 110(e) of the Clean Air Act has been granted). As shown in Table 3.1. the schedule requires that lead emissions be projected for the fourth quarter of 1982 (1984 if an extension has been granted). States, of course, are encouraged to demonstrate attainment earlier if possible. Also, unless quarterly variations are being taken into account, the projection to the attainment year can be based on annual rather than quarterly estimates in the same way as can be done for the baseline inventory.

3.1 SOURCES OTHER THAN HIGHWAY VEHICLES

3.1.1 General

This section describes the projection of emissions from point sources, including industrial fugitives, and traditional area sources. Projection of emissions associated with vehicular sources, including reentrained road dust, is described in Sec. 3.2.

Table 3.1. Lead Analysis Time Period Requirements

Date	Action	Time Interval
Oct. 5, 1978	Lead NAAQS promulgated.	-
July 5, 1979	Lead SIP due.	9 mos.
Nov. 5, 1979	Approval/Disapproval of SIP by EPA.	4 mos.
Nov. 5, 1982(84)	Demonstration of attainment without (with) extension.	3 (5) yrs.

The techniques used to project lead emissions from point and area sources are the same as would be used to project particulate emissions from those source categories and states should already be familiar with them. References 7 and 16 discuss the available methodologies and data sources that can be used in making such projections. In general, projections of variables such as process weight which are closely related to emissions are unavailable and, as described in the references, recourse must be had to surrogate variables such as population or employment to project future emissions. Of course, in cases where source-specific information is available as with a scheduled startup or shutdown, this information should be used rather than the projections based on surrogate variables. In making the projections, care must be taken to use the appropriate lead, not particulate, emission factors and to account for any known difference in control efficiencies for lead and particulates just as was done when developing the baseline lead inventory.

In projecting future emissions, one source of difficulty is disaggregating the projected capacity or emissions between new/modified and existing sources. Disaggregation is necessary because different regulations frequently apply to sources in the two categories. Reference 16 presents a method for projecting emissions from new/modified and existing sources in the absence of source retirement and assuming full capacity utilization. Reference 15 presents a method which accounts for both retirement and fractional capacity utilization. Both references present equations based on compound growth. For linear growth with retirement but assuming full capacity utilization in the base year, the model presented in Appendix B of this work may be used.

Projections of future emissions should account for the following federal programs:

- New Source Performance Standards (NSPS),
- Fuel switching required under the Energy Supply and Environmental Coordination Act of 1974 (ESECA),
- Particulate SIP revisions in nonattainment areas and air quality maintenance areas (AQMAs), and
- Prevention of Significant Deterioration (PSD).

Each of these programs has the potential to affect lead emissions. NSPSs generally require more stringent controls on new and modified (growth and replacement) sources than are required under current state regulations. If state regulations for new/modified sources are more stringent, then they should be used rather than NSPS. Switches from gaseous or liquid to solid fuels will usually be accompanied by an increase in both lead and particulate emission rates. In nonattainment areas, reasonably available control technology (RACT) for particulates should be operating on existing sources by 1982 with a concommitant reduction in lead emissions. In addition, new and modified sources in these areas may be subject to the stringent lowest achievable emission rate (LAER) control requirements. Some jurisdictions may also have implemented AQMA strategies for particulates by 1982; the impact of these strategies on lead emissions should be assessed when estimating future emissions. Finally, PSD regulations require best available control technology (BACT) on certain new sources as well as review of the sources' incremental particulate air quality impact. Insofar as these regulations affect future particulate emissions, they may also affect projected lead emissions. The projection of future lead emissions should be based on actual expected emission rates rather than compliance rates if it is expected that the two will differ. Thus, the potential impact of delayed compliance orders (DCOs) should also be considered when emissions are projected.

3.1.2 Illustrations from Example Area

As a first strategy, point source projections for the example area were made without considering the emission impact of nonattainment SIP revisions. Promulgated NSPS were applied to growth and replacement activity. These projections are presented in this section, because, as discussed in Sections 5 and 6, the indications were that additional stringency was not required to demonstrate attainment of the lead NAAQS. In developing plans, however, states should estimate future emissions as accurately as practicable and take credit for all control programs likely to affect lead emissions. Such credit may be particularly important for significant point sources where modeling is required. For example, Plant A, the largest point source in the inventory, was out of compliance with existing regulations in 1975 and is expected to come into compliance before 1982 with a significant reduction in lead emissions.

Emission projections for sources other than highway vehicles used the following data:

- Employment projections,
- Population projections, and
- Estimates of replacement rates.

Employment projections were available at the two-digit Standard Industrial Classification (SIC)[32] level from Ref. 33. These estimates were county-specific. Industrial process emissions projections were thus done at a level between the level 1 and level 2 described in Refs. 7 and 16. States, of course, should pick the level appropriate to the severity of their lead problems, the available data, and resource constraints in consultation with the EPA Regional Office. Some plant-specific data were available for local power plants[34] and was used in a level 3 projection. Emissions from other power plants were handled in the same way as industrial process emissions. In deciding which, if any, plants to interview in level 3 projections, states should be aware that significant lead sources may not always be those which are large particulate sources. Hence, some change in the source categories traditionally treated at a high level of detail may be in order. Table 3.2 presents the employment growth rates used to make emission projections in the example area. These rates were obtained by assuming linear growth between the 1975 and 1995 employment levels projected in Ref. 33.

Population projections were available at the county level from Ref. 35. Table 3.3 presents the population growth rates for the example area. These data assume linear growth between the 1975 and 1990 population levels projected in the reference. The area source categories to which the population surrogate was applied are also indicated. With locally available, county-specific data, the level of projection corresponds to about level 2. States should make the same considerations as noted above in dealing with these categories.

Table 3.3 also presents the growth rates used in projecting future emissions from other area source categories. These rates are averages of the rates for industrial, commercial/institutional, and agricultural SICs from Ref. 33. In plan development, states will need to use methods tailored to the available data as described in Refs. 7 and 16.

Table 3.2 Employment Growth Rates for Projecting Point Source Emissions[a]

		Annual Percentage Employment Growth (%/yr)		
		County		
2-Digit SIC	Industry	C	D	L
99	Nonclassifiable	0.91	0.90	1.06
07	Agricultural Services	0.74	0.54	0.59
14	Mining	-2.09	-2.08	-2.10
15	General Building	0.44	0.44	0.44
24	Wood Products	0.76	0.77	0.72
25	Furniture	0.83	0.85	0.72
32	Stone, Clay, Glass Products	1.28	0.95	1.38
33	Primary Metals	0.35	0.30	0.28
34	Fabricated Metal Products	1.44	1.44	1.39
35	Machinery	0.83	0.63	1.04
36	Electrical Equipment	0.90	0.72	1.30
37	Transportation Equipment	0.72	-0.11	0.39
38	Instruments	1.96	1.81	2.68
39	Miscellaneous Manufacturing	0.61	0.60	0.61
20	Food	0.08	0.12	0.10
22	Textile Mill Products	0.09	0.23	0.91
23	Clothing	-1.27	-1.11	-1.30
26	Paper	1.06	1.12	1.18
27	Printing and Publishing	0.61	0.60	0.56
28	Chemicals	1.10	1.20	1.15
29	Petroleum and Coal Products	0.83	0.37	0
30	Rubber and Plastic Products	2.46	2.60	2.32
31	Leather Products	-0.60	-0.65	-0.71
40,46,42	Railroads, Trucks, & Pipelines	0.44	0.85	0.84
49	Electric, Gas, Sanitary Services	0.82	0.59	1.03
50,51	Wholesale	0.67	0.67	0.64
53,58	Stores, Restaurants	1.04	1.04	1.04
65	Real Estate	1.15	1.16	1.15
86,89	Organizations & Miscellaneous	1.80	1.56	1.81
72	Personal Services	0.59	0.59	0.59
73,75	Business and Auto Services	1.65	1.61	1.62
80,82,83	Schools, Health, & Social Services	2.36	2.06	2.46
92	Public Safety	-0.45	-0.45	-0.04

[a] Based on data in Ref. 33.

Table 3.3 Growth Rates for Projecting Area Source Emissions[a]

Source Category	Projection Parameter	Growth Rate (%/yr)		
		C	D	L
Residential fuel combustion	Population	0.15	2.79	3.63
Off-highway vehicles	"	"	"	"
Residential incineration	"	"	"	"
Commercial/Institutional fuel combustion	C/I emp.[b]	0.95	0.96	1.08
Commercial/Institutional incineration	" "	"	"	"
Industrial fuel combustion	Mfg. emp.[c]	0.83	0.31	1.09
Industrial incineration	" "	"	"	"
Unpaved roads	VMT[d]	1.00	1.00	1.00
Land tilling	Agri. emp.	0.74	0.54	0.59

[a] Based on data in Refs. 33 and 35.

[b] Commercial/institutional employment rates are averages of rates for SICs related to transportation, commerce, and public utilities; trade; finance, insurance, and real estate; services; and civil governments.

[c] Manufacturing employment rates are averages for SICs in manufacturing categories 20-39.

[d] Based on average predicted VMT growth in 8-county transportation study area which includes example area.

Finally, the replacement rates used in projecting point source emissions are given in Table 3.4. These rates were developed for specific SICs from data in Refs. 36 and 37.

Illustrative Point Source Lead Emission Projection

Note: The details of the emission projections depend upon the emissions projection model chosen. The example presented here makes use of the equations derived in Appendix B. Review of these equations is suggested prior to reading this subsection. States may, of course, use another appropriate model for projecting emissions.

The projection of lead point source emissions is illustrated here for Plant E in Table 2.1. The lead emitting source category in this plant is SCC 30400303, electric induction furnaces. Figure 2.1 shows that Plant E is located in County C. The inventory indicates that the plant's SIC is 3322, a malleable iron foundry. The projections is illustrated for two cases:

1. The case actually modeled in the example strategy for which no additional controls are applied, and
2. A hypothetical case in which additional controls are assumed to be required on new and modified electric arc induction furnaces and retrofits are required on existing furnaces.

The second case is included to illustrate the manner in which the phase-in of control programs is handled.

Case 1. In this case source activity associated with existing, modified, and new capacity or activity would all be subject to the same 1975-level control requirements. Using the growth model presented in Appendix B, this condition can be expressed mathematically as $\eta_{eo} = \eta_{en} = \eta_{gi} = \eta_{gf}$. Since the regulations for new/modified sources do not change during the projection period, T can be set equal to either t_o or t_n. Under these conditions Eq. B.10 on p. 98 reduces to

Table 3.4 Replacement Rates[a]

Standard Industrial Classification (SIC)	Fractional Replacement Rate (yr^{-1})	Comments
0723	.037	Gravel Handling & processing average
0759	.039	Pathological incinerators
1421	.055	Sand, gravel & stone quarrying & processing
1422	.05	Lime processing
1441	.05	Sand and gravel mining
1442	.05	Sand and gravel mining
1541	.025	Cement plants
2011	.03	Average of all food related values
2013	.04	Meat smoke houses
2024	.03	Average of all food related categories
2032	.03	Average of all food related categories
2033	.03	Average of all food related categories
2041	.037	Grain handling and processing
2042	.037	Grain handling and processing
2043	.037	Grain handling and processing
2046	.037	Grain handling and processing
2048	.03	Average of all food-related categories
2071	.03	Average of all food related categories
2083	.04	Beer processing
2085	.032	Whiskey processing
2086	.04	Beer processing
2092	.008	Fish processing
2096	.03	Average of all food related categories
2098	.03	Average of all food related categories
2099	.03	Average of all food related categories
2231	.042	Textile processing
2261	.042	Textile processing
2291	.042	Textile processing
2295	.042	Textile processing
2311	.042	Textile processing
2399	.042	Textile processing
2431	.031	Wood processing - pulpboard
2434	.031	Wood processing - pulpboard
2499	.031	Wood processing - pulpboard
2511	.039	Average value for selected manufacturing categories
2512	.039	Average value for selected manufacturing categories
2514	.039	Average value for selected manufacturing categories
2522	.039	Average value for selected manufacturing categories
2542	.039	Average value for selected manufacturing categories
2621	.031	Wood processing - pulpboard
2631	.031	Wood processing - pulpboard
2641	.031	Wood processing - pulpboard
2642	.031	Wood processing - pulpboard
2643	.031	Wood processing - pulpboard
2644	.031	Wood processing - pulpboard
2645	.031	Wood processing - pulpboard
2647	.031	Wood processing - pulpboard
2649	.031	Wood processing - pulpboard
2651	.031	Wood processing - pulpboard
2652	.031	Wood processing - pulpboard
2654	.031	Wood processing - pulpboard
2655	.031	Wood processing - pulpboard
2661	.031	Wood processing - pulpboard
2699	.031	Wood processing - pulpboard
2751	.045	Graphic arts
2752	.045	Graphic arts
2757	.045	Graphic arts
2793	.045	Graphic arts
2799	.045	Graphic arts
2813	.045	Average for chemicals & products
2816	0	Lead pigment
2818	.045	Averaged over all chemicals & products
2819	.045	Averaged over all chemicals & products
2821	.021	Averaged over all resinous chemicals
2824	.035	Averaged over all synthetic fibers

Table 3.4 (Cont'd)

Standard Industrial Classification (SIC)	Fractional Replacement Rate (yr^{-1})	Comments
2833	.045	Pharamaceuticals
2834	.045	Pharamaceuticals
2841	.022	Average of soap and detergents
2843	.045	Average for chemicals & products
2844	.045	Average for chemical manufacturing
2845	.045	Average for chemical manufacturing
2851	.065	Paint and varnish
2861	.045	Average for chemical manufacturing
2865	.033	Average between malaic and phthalic anhydride
2871	.032	Average of all agricultural chemicals
2873	.031	Average of all fertilizer chemicals
2891	.045	Average for all chemical manufacturing
2892	.045	Explosives
2893	.045	Printing ink
2899	.045	Average for all chemical manufacturing
2911	.031	Petroleum refining
2951	.05	Asphalt roofing
2952	.042	Asphalt roof saturating & blowing
2992	.031	Miscellaneous petroleum industry point sources
2999	.031	Miscellaneous petroleum industry point sources
3069	.003	Rubber process industry
3079	.022	Average of all synthetics
3111	.039	Average of selected manufacturing categories
3132	.039	Average of selected manufacturing categories
3141	.039	Average of selected manufacturing categories
3211	.033	Glass processing
3221	.033	Glass processing
3229	.033	Glass processing
3241	.025	Cement plants
3250	.033	Brick & related clay products
3251	.03	Average of concrete & brick industries
3271	.03	Average of concrete & brick industries
3272	.03	Average of concrete processes
3273	.03	Average of concrete processes
3274	.05	Lime processing
3275	.006	Gypsum processing
3281	.06	Stone quarrying and processing
3292	.033	Average of all mining categories
3293	.033	Average of all mining categories
3295	.033	Average of all mining categories
3297	.045	Average for chemicals & products
3310	.028	Iron & steel plants
3312	.028	Iron & steel/blast furnaces
3316	.028	Iron & steel plants
3317	.028	Iron & steel plants
3321	.028	Iron & steel plants
3322	.028	Iron & steel plants
3323	.028	Iron & steel plants
3325	.028	Iron & steel plants
3334	.035	Primary aluminum smelters
3339	.028	Ferro alloy
3341	.032	Average of nonferrous secondary metals
3351	.035	Average of copper & brass handling, refining, and smelting
3352	.032	Average of non-ferrous secondary metals
3356	.033	Average of lead, brass, magnesium & zinc secondary processes
3361	.036	Aluminum production
3362	.035	Average of brass, bronze, all copper operations (secondary metals)
3369	.035	Average of brass, bronze, all copper operations (secondary metals)
3391	.03	Primary iron & steel
3394	.03	Primary iron & steel
3399	.03	Primary iron & steel
3411	0	Can Manufacturing

Table 3.4 (Cont'd)

Standard Industrial Classification (SIC)	Fractional Replacement Rate (yr^{-1})	Comments
3429	.039	Average of selected manufacturing categories
3433	.039	Average of selected manufacturing categories
3441	.039	Average of selected manufacturing categories
3452	.039	Average of selected manufacturing categories
3461	.039	Average of selected manufacturing categories
3462	.039	Average of selected manufacturing categories
3466	.039	Average of selected manufacturing categories
3469	.039	Average of selected manufacturing categories
3471	.039	Average of selected manufacturing categories
3479	.039	Average of selected manufacturing categories
3481	.045	Explosives
3489	.045	Explosives
3491	.039	Average of selected manufacturing categories
3493	.02	Internal combustion engines (spark-ignition)
3496	.039	Average of selected manufacturing categories
3499	.039	Average of selected manufacturing categories
3519	.04	Assembly plants
3522	.03	Average of food related processes
3531	.04	Assembly plants
3536	.04	Assembly plants
3537	.04	Assembly plants
3541	.039	Average of select manufacturing industries
3542	.039	Average of select manufacturing industries
3544	.039	Average of select manufacturing industries
3545	.039	Average of select manufacturing industries
3553	.04	Assembly plants
3555	.045	Printing ink
3558	.045	Printing ink
3561	.039	Average manufacturing
3562	.039	Average manufacturing
3563	.039	Average manufacturing
3571	.039	Average manufacturing
3579	.039	Average manufacturing
3584	.04	Assembly plants
3585	.04	Assembly plants
3594	.04	Assembly plants
3599	.039	General manufacturing average
3612	.039	General manufacturing average
3613	.039	General manufacturing average
3621	.039	General manufacturing average
3631	.039	General manufacturing average
3621	.039	General manufacturing average
3631	.039	General manufacturing average
3634	.039	General manufacturing average
3634	.039	General manufacturing average
3635	.039	General manufacturing average
3641	.039	General manufacturing average
3642	.039	General manufacturing average
3651	.039	General manufacturing average
3661	.039	General manufacturing average
3662	.039	General manufacturing average
3679	.039	General manufacturing average
3694	.039	General manufacturing average
3711	.04	Assembly plants
3714	.04	Assembly plants
3731	.04	Assembly plants
3741	.039	General manufacturing average
3742	.039	General manufacturing average
3743	.039	General manufacturing average
3751	.039	General manufacturing average
3799	.039	General manufacturing average
3822	.039	General manufacturing average
3823	.039	General manufacturing average
3825	.039	General manufacturing average
3842	.039	General manufacturing average
3843	.039	General manufacturing average
3861	.039	General manufacturing average

Table 3.4 (Cont'd)

Standard Industrial Classification (SIC)	Fractional Replacement Rate (yr^{-1})	Comments
3931	.039	General manufacturing average
3941	.039	General manufacturing average
3943	.039	General manufacturing average
3949	.039	General manufacturing average
3983	.039	General manufacturing average
3988	.039	General manufacturing average
3993	.039	General manufacturing average
4013	.039	General manufacturing average
4226	.02	Small boilers
4612	.031	Miscellaneous petroleum industry point sources
4613	.031	Miscellaneous petroleum industry point sources
4911	.06	Large fossil fuel boilers
4923	.04	Small to medium size boilers
4925	.04	Small to medium size boilers
4931	.037	Small boilers
4941	.04	Small to medium size boilers
4953	.038	Average for various types incineration
5074	.039	Miscellaneous manufacturing average
5092	.039	Miscellaneous manufacturing average
5093	.039	Miscellaneous manufacturing average
5099	.039	Miscellaneous manufacturing average
5153	.037	Grain handling & processing
5171	.042	Nonpipeline petroleum transfer
5191	.03	Average for food industry
5399	.039	Average miscellaneous manufacturing
5812	.028	Deep fat frying
6512	.055	Sand and stone mining
6513	.055	Sand and stone mining
7211	.055	Sand and stone mining
7216	.05	Dry cleaning
7391	.039	Average of miscellaneous manufacturing categories
7399	.036	Average of miscellaneous manufacturing categories
7534	.039	Average of miscellaneous manufacturing categories
7535	.042	Industrial surface coating
8062	.039	Pathological incinerators
8211	.037	Small to medium size boilers
8331	.037	Small to medium size boilers
8321	0	No information available for minor category
8661	0	No information available for minor category
8911	0	No information available for minor category
9223	.037	Small to medium size boilers
9999	.039	Average of all manufacturing categories

[a] Based on data in Refs. 9 and 10.

$$\left.\begin{array}{ll} Q_n^e = Q_o \times [1-RR \times (t_n - t_o)] = & \text{Emissions from sources existing at } t_o \text{ and remaining at } t_n \text{(tons/yr)} \\ & \text{and} \\ Q_n^{nm} = Q_o \times (t_n - t_o)(RR + GR) = & \text{Emissions from sources that were new or modified between } t_o \text{ and } t_n \text{ (tons/yr)} \end{array}\right\} \quad (3.1)$$

where GR is the growth rate and RR is the rate of replacement. Table 3.4 gives the replacement rate for SIC 3322 as RR = 0.028; Table 3.2 gives the growth rate as GR = 0.0035. For the projection period, $t_o = 1975$ and $t_n = 1982$. Table 2.1 gives $Q_o = 2.8$ tons/yr where the fugitive and stack components can be added together because the same conditions apply to each component. Using these values in Eq. 3.1,

$$Q_{82}^e \text{ (E)} = 2.82\ [1 - .028 \times (1982 - 1975)] = 2.27 \text{ tons Pb/yr}$$

$$= \text{Total plant emissions in 1982 due to existing capacity}$$

$$\text{and } Q_{82}^{nm} \text{ (E)} = 2.82 \times (1982 - 1975) \times (.028 + .0035) = 0.62 \text{ tons Pb/yr}$$

$$= \text{Total plant emissions in 1982 due to new/modified capacity.}$$

Thus, the emissions for the year 1982 from Plant E (existing plus new and modified capacity) are projected to be 2.89 tons of lead/yr.

Case 2. This case was not actually used in developing the example strategy but illustrates how emissions might be projected when retrofit controls are required and more stringent controls are required on new/modified sources. The available inventory shows that the sources in question were totally uncontrolled ($\eta_{eo} = 0.00$) in the base year 1975. It is assumed here that the strategy being simulated would call for the retrofit of all existing sources with 93% controls on stack emissions and 90% controls on fugitive emissions by 1982. Furthermore, new/modified sources would be required to control stack emissions by 97% beginning in 1980 and fugitive emissions by 95% beginning in 1981. Prior to these years, new/modified sources have been subject to the proposed retrofit regulations.

Since the control requirements and effective dates for the stack and fugitive emissions are different, the projections for each type of emission must be made separately. The calculation is summarized below using the notation of **Appendix** B. For stack emissions:

$$t_o = 1975,\ T = 1980,\ t_n = 1982;$$

$$\eta_{eo} = 0,\ \eta_{en} = 93,\ \eta_{gi} = 93, \text{ and } \eta_{gf} = 97$$

where η_{eo}, η_{en}, η_{gi}, and η_{gf} are the control efficiencies required, respectively, on sources existing in the base year 1975, existing sources not replaced by 1982 but required to retrofit, new/modified sources constructed between 1975 and 1980, and new/modified sources constructed between 1980 and 1982. From Eq. B.12 (p. 98),

$$R_e = \frac{1 - 93/100}{1 - 0/100} = 0.07,$$

$$R_i = 0.07, \text{ and } R_f = 0.03.$$

R_e is the ratio of emissions per unit capacity of retrofitted sources in 1982 to emissions per unit capacity of sources under base year controls. R_i and R_f are similar ratios for new/modified sources constructed between 1975 and 1980 and those constructed between 1980 and 1982, respectively. Substituting in Eq. B.10 (p. 98),

$$Q^e_{82} \text{ (E-stack)} = 1.41 \times 0.07 \times (1 - .028 \times 7) = 0.08 \text{ tons Pb/yr}$$

= Total plant stack emissions in 1982 due to existing capacity.

$$Q^{nm}_{82} \text{ (E-stack)} = 1.41 \times 0.07 \times 5 \times (.028 + .0035)$$

$$+ 1.41 \times 0.03 \times 2 \times (.028 + .0035)$$

$$= 0.02 \text{ tons Pb/yr}$$

= Total plant stack emissions in 1982 due to new/modified capacity.

For fugitive emissions:

$$t_o = 1975,\ T = 1981,\ t_n = 1982;$$

$$\eta_{eo} = 0,\ \eta_{en} = 90,\ \eta_{gi} = 90,\ \eta_{gf} = 95; \text{ and}$$

$$R_e = 0.10,\ R_i = 0.10,\ R_f = 0.05.$$

$$Q_{82}^{e} \text{ (E-fugitive)} = 1.41 \times 0.10 \times (1 - .028 \times 7)$$

$$= 0.11 \text{ tons Pb/yr}$$

= Total plant fugitive emissions in 1982 due to existing capacity.

$$Q_{82}^{nm} \text{ (E-fugitive)} = 1.41 \times 0.10 \times 6 \times (.028 + .0035)$$

$$+ 1.41 \times 0.05 \times 1 \times (.028 + .0035)$$

$$= 0.03 \text{ tons Pb/yr}$$

= Total plant fugitive emissions in 1982 due to new/modified capacity.

In total Q_{82}^{e} (E) = Q_{82}^{e} (E-stack) + Q_{82}^{e} (E-fug) = 0.19 tons Pb/yr, and Q_{82}^{nm} (E) = 0.05 tons Pb/yr. The total projected emission in this case for Plant E is 0.24 tons/yr, substantially less than the 2.89 tons Pb/yr projected in the example plan (Case 1). Although the projections are made on a source-by-source basis, a given source would either be completely replaced or a new one would be added to the inventory. The projection procedure gives a reasonable estimate of total future emissions from all sources and for a particular source such as Plant E, the 1982 emissions could be substantially different from those projected by the methodology used here or the methodologies referenced above. Lacking source-specific data, these methods do, however, give a reasonable way of projecting total future emissions.

Illustrative Point Source Fuel Conversion

No instances of fuel switching under ESECA were identified in the example area. The potential impact of fuel switching is illustrated by the following hypothetical example.

Plant J in County L is an electric utility with large oil-fired boilers (SCC 10100401). Interview results[34] indicated that Plant J should burn about 69,806,000 gal/yr of residual oil with a heating value of 150,000 Btu/gal in 1982. The emission inventory shows an average of 94% control on particulate emissions from these boilers. Emissions can be calculated using Eq. 3.1. The SCC units are 10^3 gal so

OR = 69,806 SCC units/yr,

EF = 0.004 lb/SCC unit from HATREMS,

DM = 1.00, the default multiplier from HATREMS, and

W = 94.

$$\text{Thus, } Q_{82}^{oil} = (1/2000) \times 69{,}806 \times .004 \times 1 \times [1 - (94 \times 100/100)/100]$$

$$= 0.0084 \text{ tons Pb/yr}$$

= Total lead emissions from oil combustion at Plant J in 1982.

Particulate and lead controls have been assumed equal (Y = 100), information to the contrary being unavailable. It should be noted that the emissions from these boilers are too small to have been included in the point source inventory given for Plant J in Table 2.1.

However, conversion to coal would lead to an increase in lead emissions. The bituminous coal currently being burned in Plant J has a heating value of 24.5×10^6 Btu/ton. The amount of coal required to produce the same amount of heat as supplied by the oil gives the annual operating rate. This value OR_c is given by

$$OR_c = \frac{69{,}806{,}000 \text{ gal/yr} \times 150{,}000 \text{ Btu/gal}}{24.5 \times 10^6 \text{ Btu/ton}} \times \left(\frac{.6}{.5}\right)$$

$$= 5.13 \times 10^5 \text{ tons coal/yr in 1982.}$$

The factor (.6/.5) accounts for an expected decrease in the thermal efficiency of the boilers from 60% to 50% as a result of the fuel conversion. The appropriate SCC for large bituminous coal-fired boilers is assumed to be 10100201. Applying Eq. 3.1 again to calculate emissions and assuming no change in control efficiency,

$$Q_{82}^{coal} = (1/2000) \times 5.13 \times 10^5 \times .0018 \times 9.00 \times [1 - (94 \times 100/100)/100]$$

$$= 0.249 \text{ tons Pb/yr.}$$

Lead emissions at Plant J would thus increase by a factor of about 30 due to the coal conversion. Although the lead emissions are still fairly small on an absolute scale, the conversion would increase Plant J's total lead emissions by over 20%. Analysis of similar situations should be of aid in identifying potential problem areas where large increases in lead emissions might cause source-specific NAAQS violations.

Illustrative Area Source Lead Emission Projection

This illustration uses the same example begun in Sec. 2.1.2, that of commercial/institutional distillate fuel use in County C. No controls are anticipated to be required on commercial/institutional fuel combustion given the small size and dispersed nature of the sources. Replacement need not be considered, as old and new units will probably have almost identical emission characteristics and emissions can be projected considering only growth. In cases where different conditions exist as when many units with higher thermal efficiencies are expected to be installed such conditions should be accounted for in projecting future emissions. In the example considered here, Eq. B.10 can be put in the form

$$Q_n = Q_o \times [1 + GR \times (t_n - t_o)] \text{ and}$$

$$Q_{82} = .028 \times (1 + .0095 \times 7) = 0.030 \text{ ton Pb/yr}$$

where the growth rate GR was taken from Table 3.3 and Q_o came from the example calculation in Sec. 2.1.2.

3.2 HIGHWAY VEHICLE RELATED SOURCES

General

Two categories of sources are considered here: the tailpipe emissions from highway vehicles and lead from reentrained road dust. In projecting emissions from these categories the following programs must be taken into account:

- Federal programs for the reduction of the lead content of gasoline and the requirements for the use of lead-free gasoline in catalyst equipped vehicles,
- Federal requirements for improved fuel economy,
- Any transportation system management (TSM) elements such as employer carpool incentive programs or traffic flow improvement programs that will be instituted before the attainment date for the lead NAAQS, and

- **Any other transportation control plan (TCP) measures which reduce VMT's or improve traffic flow so that vehicular lead emissions would be reduced.**

In many areas lead emissions caused by highway vehicles are likely to be the largest part of the inventory and hence it is reasonable to place considerable emphasis on estimating future emissions from these categories.

Projection of Highway Vehicle Lead Emissions

The emissions under steady-state, acceleration, and stop-and-go conditions can be projected by the same methodology used for estimating the base-year emissions as discussed in Sec. 2.1.2. The factors $e_{n,s}$, Pb_n, and $f_{n,s}$ in Eqns. 2.3, 2.4, and 2.5 have been developed to reflect existing federal requirements for the reduction of the lead content of gasoline, use of lead-free gasoline, and improved fuel economy. The same equations can be used to estimate future lead emissions once the projected VMTs are known. The implementation of TSM measures or TCPs would affect projected VMT and/or average speed figures for the projection year. The transportation agency and air quality planning agency are required to integrate their respective transportation and air quality planning efforts under Sec. 108 (e) of the Clean Air Act and subsequent guidelines.[38,39,40] Appropriate estimates of future VMTs and speeds should be available as a result of these integrated planning efforts and, of course, the states should already be aware of the progress of these efforts. In cases where the VMT estimates will not be available in time for the lead SIP, the Regional Office should be consulted. In such circumstances, it may be desirable to use VMT projections which do not account for any transportation measures as a first estimate. If attainment can still be demonstrated under such circumstances, a future upper bound to lead air quality could be estimated. In areas where integrated planning is not required, Ref. 16 suggests several sources of transportation data. The local transportation planning agency is likely to be the primary source for such information.

Projection of Lead Emissions from Reentrained Road Dust

The estimation of lead from reentrained road dust was discussed in Sec. 2.1.2. The same method can be used in estimating future emissions if projected VMTs are known. However, as noted in Sec. 2.1.2, Ref. 4 indicates that the emission factor for lead from reentrained road dust is expected to decrease over time. It is suggested here that the emission factor for this source category be calculated for the year n from

$$EF_{LERRD}(n) = 0.03 \times \frac{Pb_n}{1.65}$$

or $$EF_{LERRD}(n) = 0.0182\ Pb_n \text{ grams/vehicle-mile} \qquad (3.2)$$

where

$EF_{LERRD}(n)$ = emission factor for lead emissions from reentrained road dust in the year n, and

Pb_n = probable pooled average lead content of gasoline in year n (g/gal).

The factor 0.03 is the emission factor given in Ref. 4 for 1975-76 and 1.65 g/gal is the average of Pb_{75} (= 1.7 g/gal) and Pb_{76} (= 1.4 g/gal). Equation 3.2 thus simply assumes that the lead emissions from reentrained road dust will diminish in proportion to the probable pooled average lead content of gasoline. For 1980 when Pb_{80} = 0.5 grams/gal, Eq. 3.2 gives EF_{LERRD} (80) = .0091 grams/vehicle-mile in good agreement with the expected value of about 0.01 grams/vehicle-mile given in Ref. 4. It should be stressed that Eq. 3.2 does not reflect any definite guidance from U.S. EPA and this suggested procedure should be cleared with the EPA Regional Office prior to use.

Illustrations from Example Area

The following continues the example of arterial lead emissions from heavy-duty gasoline-powered trucks in County C for which the base-year emissions calculation was illustrated in Sec. 2.1.2. The arterial form of Eq. 2.5 is used again and Pb_{82}, VMT_{82}, and $f_{82,s}$ must be found. Pb_{82} again comes from Table 4.3-8 in Ref. 17 which shows Pb_{82} = 2.0 grams/gal. Users should take care in using Eq. 2.5 to use the proper table for determining Pb_n. Table 4.3-1 in Ref. 17 is used for light duty vehicles and trucks while Table 4.3-8 is used for heavy-duty gasoline-powered trucks only. VMT_{82} was calculated for arterials using the area-wide growth rate of 1.00% yr^{-1} given in Table 3.3. Thus,

$$VMT_{82}\text{ (County C)} = VMT_{75}\text{(County C)} \times (1 + 7 \times .01) = 1{,}055{,}690 \times 1.07$$
$$= 1{,}129{,}590 \text{ vehicle-miles/day.}$$

And as noted in Ref. 17, $f_{n,s}$ = 5.7 vehicle-miles/gal independent of n and s for this source category. Using Eq. 2.5,

$$E_{82}(\text{County C; heavy-duty gasoline-powered trucks})$$

$$= \frac{0.70 \times 2.0(\text{g/gal}) \times 1{,}129{,}590(\text{vehicle-miles/day})}{5.7(\text{vehicle-miles/gal})}$$

$$= 277{,}440 \text{ grams lead/day}$$

$$= 112 \text{ tons lead/yr.}$$

In developing the example plan, freeway calculations made use of link-specific VMT and speed projections. These projected data were available for 1990 from the local transportation planning agency. Linear interpolation was used between the values for 1990 and values presented for 1975 in Table A.2 to estimate values appropriate to the projection year 1982. Because the 1990 data has the same form as that already presented in Table A.2 it has not been reproduced here. Thus two levels of detail were used in projecting vehicular-related lead emissions for the example area: a regional level for arterial emissions and a link-specific level for freeway emissions. States should use the level of detail appropriate to their resources and the extent and severity of their lead problems.

A further simple example projects the County D lead emissions from reentrained road dust on arterials. The base-year calculation has been presented in Sec. 2.1.2. VMT_{82} was calculated for arterials using the area-wide growth rate of 1.00% yr^{-1} given in Table 3.3:

$$\begin{aligned} VMT_{82}(\text{County D}) &= VMT_{72}(\text{County D}) \times (1 + 7 \times .01) \\ &= 9{,}429{,}900 \times 1.07 \\ &= 10{,}089{,}990 \text{ vehicle-miles/day.} \end{aligned}$$

Emissions can now be calculated using Eq 2.2 with DM = 1 and an emission factor calculated from Eq. 3.2:

$$\begin{aligned} Q^{82}_{rld} &= 10{,}089{,}990(\text{VMT/day}) \times 365(\text{day/yr}) \\ &\quad \times .0091(\text{grams Pb/VMT}) \times (1/907{,}200)(\text{tons/gram}) \\ &= 37 \text{ tons lead/yr} \\ &= \text{Emissions from reentrained lead dust (rld) in County D in 1982} \end{aligned}$$

where additional factors have been used to give the result in tons/yr. This is substantially less than the 114 tons/yr of lead from reentrained dust from arterial roads in County D in the base year. The reduction in the emission factor from 0.03 gm/VMT in 1975-76 to .0091 gm/VMT in 1982 is more than sufficient to counteract the expected increase in VMT. The sensitivity of this calculation to the value of the emission factor also indicates that care must be taken in calculations where the emission factor is a function of time.

3.3 PROJECTED FUTURE EXAMPLE AREA LEAD EMISSION INVENTORY

Using the methods presented and illustrated above, an emission inventory was projected for the example area. Table 3.5 summarizes the projected 1982 emission inventory for lead in the modified NER format. Comparison with Table 3.2 indicates a 68% reduction in overall lead emission between 1975 and 1982. Reductions in land vehicle emissions account for over 87% of the total reduction; most of the remainder, 12.7%, is accounted for by reduced emissions from reentrainment and unpaved roads. Reductions at lead point sources contribute less than 1% of the total overall reduction.

Table 3.5 Projected Example Area Lead Emissions (1982)[a]

YEAR 1982

SOURCE				EMISSIONS, TONS PER YEAR				
				LEAD				
FUEL COMBUSTION: EXTERNAL	RESIDENTIAL FUEL (AREA)	ANTHRACITE COAL		.00021				
		BITUMINOUS COAL		3.20				
		DISTILLATE OIL		.00068				
		RESIDUAL OIL		--				
		NATURAL GAS		--				
		WOOD		--				
		TOTAL		3.2009				
	ELECTRIC GENERATION ~~(POINT)~~	ANTHRACITE COAL						
		BITUMINOUS COAL	- Area	.068				
		LIGNITE	- Area	.0004				
		RESIDUAL OIL	- Area	.1143				
		DISTILLATE OIL	- Area	.00049				
		NATURAL GAS						
		PROCESS GAS						
		~~COKE~~ Bit. Coal-Point		1.44				
		SOLID WASTE/COAL						
		TOTAL	Area	0.1832				
			Point	1.44				
	INDUSTRIAL FUEL	ANTHRACITE COAL	AREA	.0019				
			POINT					
		BITUMINOUS COAL	AREA	5.491				
			POINT					
		LIGNITE - Area	~~POINT~~	.0074				
		RESIDUAL OIL	AREA	1.189				
			POINT	.0319				
		DISTILLATE OIL	AREA	.0380				
			POINT					
		NATURAL GAS	AREA					
			POINT					
		PROCESS GAS	AREA					
			POINT					
		COKE	POINT					
		WOOD	AREA					
			POINT					
		LIQUID PETROL GAS	POINT					
		BAGASSE	POINT					
		OTHER	POINT					
		TOTAL	AREA	6.7273				
			POINT	.0319				

Table 3.5 (Cont'd)

SOURCE				LEAD				
FUEL COMBUSTION: EXTERNAL (CONTINUED)	COMMERCIAL-INSTITUTIONAL FUEL	ANTHRACITE COAL	AREA					
			POINT					
		BITUMINOUS COAL	AREA	.1650				
			POINT					
		LIGNITE	POINT					
		RESIDUAL OIL	AREA	.5374				
			POINT					
		DISTILLATE OIL	AREA	.0344				
			POINT					
		NATURAL GAS	AREA					
			POINT					
		WOOD	AREA					
			POINT					
		LIQUID PETROL GAS	POINT					
		OTHER	POINT					
		TOTAL	AREA	.7368				
			POINT	--				
	OTHER		POINT					
	TOTAL EXTERNAL COMBUSTION		AREA	10.848				
			POINT	1.4719				
FUEL COMBUSTION: INTERNAL	ELECTRIC GENERATION	DISTILLATE OIL						
		NATURAL GAS						
		DIESEL						
		OTHER						
		TOTAL						
	INDUSTRIAL FUEL	DISTILLATE OIL						
		NATURAL GAS						
		GASOLINE						
		DIESEL						
		OTHER						
		TOTAL						
	COMMERCIAL-INSTITUTIONAL FUEL	DIESEL						
		TOTAL						
	ENGINE TESTING	AIRCRAFT						
	TOTAL INTERNAL COMBUSTION							
TOTAL FUEL COMBUSTION		AREA		10.848				
		POINT		1.4719				

Table 3.5 (Cont'd)

SOURCE				LEAD				
INDUSTRIAL PROCESS (POINT)	CHEMICAL MANUFACTURING							
	FOOD/AGRICULTURE							
	PRIMARY METAL							
	SECONDARY METALS			60.00				
	MINERAL PRODUCTS							
	PETROLEUM INDUSTRY							
	WOOD PRODUCTS							
	PROCESS EVAPORATION							
	METAL FABRICATION			1.44				
	LEATHER PRODUCTS							
	TEXTILE MANUFACTURING							
	INPROCESS FUEL							
	~~OTHER/NOT CLASSIFIED~~ - Secondary Metals-Area			4.738				
	TOTAL Area/Point			4.738/61.44				
SOLID WASTE DISPOSAL	GOVERNMENT (POINT)	MUNIC. INCIN.		4.41				
		OPEN BURNING						
		OTHER						
		TOTAL		4.41				
	RESIDENTIAL (AREA)	ON-SITE INCIN.		314.85				
		OPEN BURNING						
		TOTAL		314.85				
	COMMERCIAL-INSTITUTIONAL	ON-SITE INCINERATION	AREA					
			POINT					
		OPEN BURNING	AREA					
			POINT					
		APARTMENT	POINT					
		OTHER	AREA					
			POINT					
		TOTAL	AREA	--				
			POINT	--				
	INDUSTRIAL	ON-SITE INCINERATION	AREA					
			POINT					
		OPEN BURNING	AREA					
			POINT					
		AUTO BODY INCIN.	POINT					
		OTHER	POINT					
		TOTAL	AREA	--				
			POINT	--				
	TOTAL SOLID WASTE DISPOSAL		AREA	314.85				
			POINT	4.14				

Table 3.5 (Cont'd)

SOURCE				LEAD				
TRANSPORTATION (AREA)	LAND VEHICLES	GASOLINE Arterial	LIGHT DUTY	404.66				
			HEAVY DUTY	143.36				
			OFF HIGHWAY	72.635				
			TOTAL	620.66				
		~~DIESEL~~ Gasoline Freeway	HEAVY DUTY	2.210				
			LIGHT DUTY	102.74				
			RAIL					
			TOTAL	104.95				
	AIRCRAFT	MILITARY						
		CIVIL						
		COMMERCIAL						
		TOTAL						
	VESSELS	BITUMINOUS COAL						
		DIESEL FUEL						
		RESIDUAL OIL						
		GASOLINE						
		TOTAL						
	GAS HANDLING EVAPORATION LOSS							
	TOTAL TRANSPORTATION			725.61				

Table 3.5 (Cont'd)

SOURCE			LEAD				
MISCELLANEOUS (AREA)	SOLVENT EVAPORATION	INDUSTRIAL SOURCES (AREA)					
		DRY CLEANING					
	FIRES	STRUCTURAL					
		FROST CONTROL					
		SLASH BURNING					
		WILD FOREST					
		AGRICULTURAL					
	DUST CAUSED BY HUMAN AGITATION OF THE AIR	UNPAVED ROADS	.01872				
		UNPAVED AIRSTRIPS					
		PAVED ROADS	279				
		MINERAL PROCESSING					
		TILLING ACTIVITIES	.05413				
		LOADING CRUSHED ROCK, SAND, GRAVEL					
		CONSTRUCTION					
	AIRBORNE DUST CAUSED BY NATURAL WINDS	STORAGE PILES					
		TILLED LAND					
		UNTILLED LAND					
GRAND TOTAL	AREA		1335				
	POINT		67.32				

[a] The standard NER format has been altered where necessary to fit the requirements of a lead inventory.

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4 ALLOCATION OF EMISSIONS

The allocation of lead emissions employs essentially the same techniques as outlined for particulates in Refs. 8, 13, and 16. States should already be familiar with these techniques and in many cases may already have operating allocation procedures available. However, a higher level of detail may be warranted in allocating lead emissions from highway vehicles than is warranted in allocating particulate emissions from this category in areas where lead emissions from highway vehicles comprise the major portion of the emission inventory. States must decide whether such additional detail is warranted based on an assessment of their resources, the level of detail in the data available for the allocation, and the severity of the lead problem.

The allocation of emissions is performed in order to put the emission inventory in the form required by the chosen air quality model. Thus, the model chosen affects the level of detail at which the allocation needs to be performed. A dispersion model must be used to calculate the magnitude and location of lead air quality concentration maxima resulting from significant lead point sources [51.84]. Such a calculation would require the allocation of emissions to an appropriate emissions grid. On the other hand, modified rollback must be used as a minimum in demonstrating attainment and maintenance in the vicinity of an air quality monitor recording violations [51.85]. If one of the more complex forms of modified rollback is employed in which distance from the monitor and, perhaps, wind direction and frequency are taken into account, emissions would need to be allocated to another appropriate emissions grid. However, a dispersion model may also be used [51.85]. Thus, if there are violations of the lead NAAQS in the vicinity of significant lead point sources, states may want to consider using a dispersion model to satisfy the requirements of both Sections 51.84 and 51.85 in order to avoid allocating to two different emissions grids. Modified rollback could still be used in the vicinity of other violations not located in the vicinity of significant lead point sources.

4.1 PROCEDURES

The emissions from point, area, and line sources must be allocated prior to modeling. As indicated above, the allocation of lead emissions for point and area sources is essentially the same as the allocation of particulate emissions, with the possible exception of area source lead emissions from highway vehicles. Reference 13 describes three orders of allocation procedures applicable where county-wide totals are available. Reference 8 details the Computer-Assisted Area Source Emissions Gridding Procedure (CAASE) which uses demographic data available from the U.S. Bureau of the Census to develop subcounty allocation parameters. The entire procedure, including the data requirements, the considerations involved in developing an emission grid, and allocation procedures, is summarized in Ref. 16.

Sources to be modeled as points are located at their true locations by UTM coordinates. This happens almost automatically when regional dispersion models are used. However, when modified rollback is used, the source emissions must be allocated by UTMs to the appropriate emission grid sector. It should be noted that allocation to these sectors must be treated somewhat differently than the more familiar allocation to dispersion model emission grids, because the modified rollback grid cells are not squares.[30*] The allocation of projected future point source emissions also requires a decision as to how the emissions from new/modified sources will be allocated. Reference 16 lists three possible procedures:

1. Assume all new source emissions occur at the same location as existing sources (i.e., growth-in-place),
2. Assume all new source emissions occur at new sites and allocate according to an allocation parameter or land-use distribution function, or
3. Determine the mix between existing and new source activity and allocate accordingly.

Procedure two or three is generally better than procedure one. When growth is assumed to occur in place, emissions from new/modified sources are allocated by UTMs to the locations of individual plants at which the associated activity changes are projected to have occurred. Of course, if precise locational information is available as the result of announced expansions, permit applications, or interviews, it should be used to allocate new/modified emissions. If either of the latter two procedures is employed, emissions from new/modified sources are totaled at the county level and allocated using an appropriate parameter and the procedures described in Refs. 3, 8, and 16.

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*A reprint of Ref. 30 is contained in Ref. 17.

Except for emissions from new/modified sources which must be allocated when their future locations are unknown, the allocation procedures described in these references are used principally for allocating county-wide area source totals to emission grids. If area source emissions are available based on activity levels at the subcounty level, this additional detail should be retained, if possible, rather than relying upon an allocation procedure. Such additional detail may be available for arterial VMTs which are frequently available for subcounty traffic zones. Given the likely importance of this category in the lead emission inventory, states with sufficient resources may want to consider retaining the subcounty level of detail when it is available or developing an allocation parameter based on the subcounty VMT data.

For lead, one further point should be noted: additional detail for allocation may be available for that part of the lead area source emissions associated with large particulate sources which are nevertheless small lead emitters. As noted in the discussion of the emission inventory in Sec. 2, the location of these sources by UTMs can be retained so that they can be allocated to the emission grid cell in which they actually occur. The alternative is to place the emission from these "residual" point sources in the appropriate area source category and allocate them to the subcounty grid cells. States should use the method appropriate to their resources and the extent of their lead air quality problem. Regardless of the procedure used for the residual points, their emissions will be part of the area source emission rate in the grid cell to which they are allocated.

The allocation of emissions inventoried as line sources is not discussed in great detail in the references noted heretofore. If, however, lead emissions from freeways or other roadway sources have been inventoried as lines and the chosen model does not simulate line sources, then these emissions must be allocated to the subcounty emission grid. The emissions could, of course, be totaled at the county level and allocated by the appropriate allocation parameter. This procedure would lose the spatial resolution gained by inventorying the sources as lines in the first place. It is suggested here that emissions from uniform line sources be allocated to emission grid cells according to the fraction of the length of the line in the grid cell. That is,

$$\begin{bmatrix}\text{Contribution of Line}\\ \text{Source i to Total}\\ \text{Emissions in Grid}\\ \text{Cell j}\end{bmatrix} = \begin{bmatrix}\text{Fraction of Length}\\ \text{of Line Source i}\\ \text{That Lies in Grid}\\ \text{Cell j}\end{bmatrix} \times \begin{bmatrix}\text{Total Emis-}\\ \text{sions from}\\ \text{Line Source}\\ \text{i}\end{bmatrix} \quad (4.1)$$

This procedure provides a reasonable compromise between a fully detailed modeling of line sources and the loss of available information occassioned when emissions are aggregated at the county level and then reallocated. Allocation of nonuniform line emissions would require a direct determination of the emissions from the segment of the line lying in a particular grid cell.

4.2 ILLUSTRATION FROM EXAMPLE AREA

In developing the example lead strategy, the entire example area was modeled using the ANLCDM dispersion model (see Sec. 5). This model treats point and area but not line sources.

The area source grid was an array of squares 1.6093 km (1 mi) on an edge. This array of small cells was chosen because population and housing unit data derived from U.S. Bureau of the Census census tract data by the methods described in Refs. 13 and 16 were available on this scale. There were 1847 grid cells covering the example area. Normally, these small cells would be aggregated in areas where a high degree of spatial resolution was felt to be unnecessary as described in Refs. 8 and 16. This aggregation would reduce the number of area sources to be modeled and thus reduce the time and resources required for modeling. For the example area, however, the full set of 1847 grid cells was modeled, because the capability of handling a large number of area sources was already available; states are not expected to use this high level of detail in developing lead strategies. Since the grid cell size utilized is too small to show clearly on a map of convenient size, no graphic presentation of the area source grid has been included here.

Depending on source type, the emission allocation was done by one of four methods. First, fugitive emissions and the emissions from "residual" point sources were allocated by UTMs; that is, they were added to the emissions rate of the area source in which they were located.* The second method was applied to area source categories for which emissions were available at the countywide level. This method was the traditional method of using an allocation parameter as described in Refs. 8, 13, and 16. Table 4.1 gives the allocation parameters used for each of the lead emission categories. These allocation parameters are consistent with those recommended in Ref. 8. The third method was applied to freeway emissions which were allocated by a method based on Eq. 4.1. Finally, the conservative "growth-in-place" assumption was used to allocate emissions from new/modified point sources.

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*A preferable method of treating the fugitive emissions associated with point sources may be to use the pseudostack method described in Sec. 5.2.

Emissions allocated by the first three methods were summed to obtain a total area source emission rate for each of the 1847 grid cells. Table 4.2 presents a partial listing of the final area source emission rates. The fugitive component of the point source emissions has been included in the appropriate grid cells in this listing. It should also be noted that the number of each grid cell can be placed in a one-to-correspondence with the UTM coordinates of the grid cell's southwestern corner for proper location during modeling.

Table 4.1 Lead Emission Allocation Parameters

Source Category	Subcounty Allocation Parameter[a]
Fuel Combustion	
Residential	Housing units
Commercial/Institutional	Population
Industrial	Population
Off-Highway Vehicles	Inverse population density
Unpaved Roads	Inverse population density
Arterial Roads	Population
Incineration	Population
Land Tilling	Inverse population density
Residual Points[b]	UTMs

[a] These parameters are generally based on those used in U.S. EPA's CAASE Procedure (see Ref. 8).

[b] Residual points are those lead sources too small to be inventoried as points but for which UTMs exist because of their inclusion in the particulate point source inventory.

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Table 4.2 Sample Listing of 1982 Allocated Area Source Lead Emissions

MASTER GRID NUMBER	EMISSIONS (TONS/YEAR)	MASTER GRID NUMBER	EMISSIONS (TONS/YEAR)	MASTER GRID NUMBER	EMISSIONS (TONS/YEAR)	MASTER GRID NUMBER	EMISSIONS (TONS/YEAR)	MASTER GRID NUMBER	EMISSIONS (TONS/YEAR)
1501	.0034	1551	.0114	1601	.0057	1651	.0041	1701	.0044
1502	.0053	1552	.0470	1602	.0073	1652	.0105	1702	.0051
1503	.0033	1553	.0142	1603	.0015	1653	.0356	1703	.0046
1504	.0034	1554	.0072	1604	.0055	1654	.0134	1704	.0046
1505	.0149	1555	.0043	1605	.0031	1655	.0395	1705	.0076
1506	.0031	1556	.0013	1606	.0023	1656	.0113	1706	.0046
1507	.0059	1557	.0043	1607	.0015	1657	.0039	1707	.0046
1508	.0036	1558	.0073	1608	.0045	1658	.0052	1708	.0046
1509	.0032	1559	.0033	1609	.0012	1659	.0052	1709	.0027
1510	.0032	1560	.0034	1610	.0011	1660	.0052	1710	.0014
1511	.0063	1561	.0034	1611	.0193	1661	.0135	1711	.0014
1512	.0111	1562	.0023	1612	.0035	1662	.0100	1712	.0014
1513	.0119	1563	.0034	1613	.0023	1663	.0030	1713	.0015
1514	.0039	1564	.0034	1614	.0370	1664	.0037	1714	.0014
1515	.0013	1565	.0031	1615	.0059	1665	.0030	1715	.0021
1516	.0043	1566	.0132	1616	.0032	1666	.0041	1716	.0017
1517	.0043	1567	.0032	1617	.0012	1667	.0055	1717	.0047
1518	.0015	1568	[illegible]	1618	.0012	1668	.0015	1718	.0103
1519	.0133	1569	.0012	1619	.0115	1669	.0015	1719	.0155
1520	.0024	1570	[illegible]	1620	.0017	1670	.0043	1720	.0031
1521	.0034	1571	.0072	1621	.0072	1671	.0011	1721	.0032
1522	.0023	1572	.0177	1622	.0010	1672	.0041	1722	.0032
1523	.0024	1573	.0765	1623	.0035	1673	.0105	1723	.0032
1524	.0024	1574	.0150	1624	.0015	1674	.0177	1724	.0039
1525	.0030	1575	.0037	1625	.0051	1675	.0310	1725	.0046
1526	.0026	1576	.0073	1626	.0015	1676	.0137	1726	.0046
1527	.0050	1577	.0050	1627	.0015	1677	.0103	1727	.0016
1528	.0031	1578	.0012	1628	.0019	1678	.0079	1728	.0016
1529	.0071	1579	.0030	1629	.0011	1679	.0052	1729	.0035
1530	.0071	1580	.0023	1630	.0041	1680	.0052	1730	.0027
1531	.0030	1581	.0033	1631	.0103	1681	.0020	1731	.0014
1532	.0022	1582	.0024	1632	.0023	1682	.0013	1732	.0014
1533	.0021	1583	.0019	1633	.0049	1683	.0016	1733	.0014
1534	.0015	1584	.0039	1634	.0427	1684	.0016	1734	.0015
1535	.0043	1585	.0049	1635	.0016	1685	.0016	1735	.0014
1536	.0043	1586	.0010	1636	.0025	1686	.0016	1736	.0019
1537	.0013	1587	.0015	1637	.0032	1687	.0013	1737	.0050
1538	.0013	1588	.0015	1638	.0052	1688	.0050	1738	.0335
1539	.0033	1589	.0051	1639	.0022	1689	.0045	1739	.0372
1540	.0034	1590	.0041	1640	.0154	1690	.0045	1740	.0103
1541	.0074	1591	.0139	1641	.0215	1691	.0043	1741	.0031
1542	.0023	1592	.0130	1642	.0165	1692	.0041	1742	.0032
1543	.0031	1593	.0061	1643	.0027	1693	.0035	1743	.0032
1544	.0034	1594	.0036	1644	[illegible]	1694	.0019	1744	.0032
1545	.0135	1595	.0139	1645	.0055	1695	.0255	1745	.0032
1546	.0012	1596	.0052	1646	.0057	1696	.0033	1746	.0012
1547	.0012	1597	.0032	1647	.0115	1697	.0132	1747	.0042
1548	.0024	1598	.0012	1648	.0025	1698	.0117	1748	.0012
1549	.0038	1599	.0015	1649	.0037	1699	.0029	1749	.0012
1550	.0030	1600	.0057	1650	.0011	1700	.0014	1750	.0032

5 MODELING PROCEDURES

5.1 REQUIREMENTS

Regulations require that:

- The plan employ the modified rollback model, at a minimum, in urbanized areas with measured quarterly lead means in excess of 4.0 μg/m^3 since January 1, 1974 [51.83]; or that
- In other areas the plan employ the modified rollback model, at a minimum, in the vicinity of any air quality monitor that has recorded lead concentrations in excess of the lead NAAQS [51.85]; and that
- In all areas dispersion models be used to calculate the magnitude and location of the maximum lead air quality concentration in the vicinity of the significant lead point sources listed in Sec. 2.1.1 whether or not the lead NAAQS are violated in the vicinity of these significant point sources [51.84].

The requirements are also discussed in Ref. 17. States are encouraged to use dispersion models for the entire analysis whenever possible, particularly in cases where such models are already available and being used to analyze other pollutants. The additional accuracy generally yielded by dispersion models is deemed sufficient to make their use highly desirable.

Regardless of the type of model used, it should be noted that credit may be taken for expected reductions in background lead levels resulting from federal programs for the reduction of lead in gasoline, the prohibition of the use of leaded gasoline in catalyst-equipped vehicles, and improved fuel economy.[17]

5.2 APPLICABLE MODELS

Dispersion Models

EPA's supplementary guidelines for lead[17] indicate that the point source models for sulfur dioxide and particulates listed in Ref. 31 are acceptable for dealing with lead concentrations in the vicinity of significant lead point sources. States should be aware, however, that hand calculation or program modification would be required before quarterly averages could be obtained from the referenced Single Source (CRSTER) Model. This model has the additonal problem of not treating fugitive emissions directly.[41] The model can, however, treat up to 19 emission points. It is suggested here, based on a recommendation made by EPA for use in multisource dispersion models,[42] that the situation could be handled by a pseudostack for the fugitive emissions. Such a stack would be 5-10 m in height, depending on the average release height of the fugitive emissions being modeled. The emissions would be assumed to be released at ambient temperature with an initial upward velocity of about 0.1 m/sec. Since this guidance does not represent official policy, states desiring to handle fugitive emissions from significant lead sources in this fashion should consult with the Regional Office's air pollution meteorologist for the latest available information.

However, as noted in Ref. 31, the CRSTER Single Source model should be applicable provided that the lead emission can be assumed to behave as a gas. This assumption may sometimes be inaccurate for lead, because deposition and fallout are also expected to be important for lead in certain circumstances. The Single Source (CRSTER) Model does not account for these processes. Reference 17 contains reprints of several articles which states desiring to account for the deposition of lead may find useful.

Recognizing that models accounting for deposition and fallout and capable of treating fugitive emissions would be useful for dealing with lead, EPA is currently developing an Industrial Source Complex Model with the capability of treating these factors. The model is expected to be available by mid-1979.

EPA is also preparing a quarterly model (PBLSQ) which should be available by summer 1979. This model will be applicable to lead and could be used in cases where dispersion modeling is required in an entire urbanized area or where states choose to use a dispersion model to treat the entire region of interest. Meanwhile, the models described in the section on multi-source models for sulfur dioxide and particulates in Ref. 31 are acceptable although these models do not account for deposition and fallout of larger particles. These models are:

- Climatological Dispersion Model (CDM or CDMQC),
- Air Quality Display Model (AQDM), and
- Texas Climatological Model (TCM).

CDMQC is a version of CDM which gives individual point and area source contributions at selected receptors. These are useful aids in strategy development.

CDM gives only the total concentration at each receptor. If a model is being used that does not have any capability to provide source contribution lists, it is recommended that the effort be expended to develop and implement one. These three models are presented as models for predicting annual average air quality. However, use of quarterly rather than annual wind roses as the meterological input will result in the simulation of quarterly air quality estimates. The remarks presented above concerning fugitive emissions, fallout, and deposition also apply to these models. It should also be noted that these multisource models do not have the capability of treating line sources. Thus, if line sources have been inventoried, they must be allocated to the area source grid by a procedure such as that described in Sec. 4.1.

EPA's modeling guideline[31] notes that in cases where (1) the recommended air quality is not appropriate, (2) the required data is unavailable, or (3) a better applicable model or analytical procedure is available, models other than those mentioned above may be used when deemed appropriate by the Regional Administrator. It also encourages early discussions between state and Regional Office staffs in such circumstances and suggests that all deviations from the guideline be "fully supported and documented." It is further suggested here that Refs. 43 and 44 be consulted for guidance in documenting alternative models and determining how alternative models compare with the models recommended in the guideline.

Validation and Calibration

As noted in Refs. 16 and 31, some validation is almost always attempted with dispersion models in order to improve the agreement between measured and predicted concentrations. References 16 and 31 discuss some of the specific steps involved in the normal validation procedure.

Long-term models are frequently calibrated against observed air quality. The most frequently used procedure involving linear regression of observed against predicted concentrations is discussed in Ref. 16. When using linear regression, a correlation coefficient, r, (significant at the 5% level) has frequently been taken as an indication that the regression is acceptable.[45] Another test is suggested in Ref. 31 which notes that if less than 50% of the variation in the measured concentrations is accounted for by the model, it is doubtful that there is justification for its use. This test would require that r^2, not r, exceed 0.50. If the number of pairs of values is less than eight the significance test on r is more stringent than the test requiring that r^2 exceed 0.50. Since there is currently no widely accepted standard, states should consult with the Regional Office if there are any questions concerning the acceptability of the calibration after some effort has been expended in validating a model.

Modified Rollback

Acceptable forms of modified rollback are described in Ref. 30;* equivalent forms also may be used.[17] Reference 30 presents four forms of modified rollback which account progressively for:

1. Multiple categories of sources which may have different growth rates and control efficiencies,
2. Average stack heights in different categories.
3. The source-receptor distance, and
4. The wind direction frequency.**

The first form is the form actually employed in many prior rollback analyses, simple rollback being a form which applies the same rate of growth and control efficiency to all the sources being modeled. Reference 30 itself concludes the third or fourth form would be more appropriate than the first two forms in most circumstances. States deciding to use modified rollback may want to consult with the Regional Office to ensure that the form chosen will be acceptable.

Two additional points should be made about the use of modified rollback. First, both the third and fourth forms require that emissions be allocated to emission grid cells composed of annular rings or sectors, respectively, centered about each receptor where an analysis is required. Each receptor analyzed will require a separate emission grid and a separate emission allocation. Second, the equations in Ref. 30 assume the background, b, is constant over the time frame of the analysis. States wishing to account for expected reductions in background lead concentrations would need to modify the equations presented in the reference.

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*This article is reproduced as Appendix G in Ref. 17.

**States desiring to use the fourth form of modified rollback should note that the illustration of wind direction frequency in Ref. 30 (or Ref. 17) is potentially misleading. If north is taken as being vertical on the printed page, then standard NCC wind roses of eight sectors would give a wind direction sector centered about north; the illustration in the references appears to show a wind direction sector centered about the north-northeast. It would, of course, be possible to develop such a set of wind direction sectors, but not from the meteorological data normally used.

5.3 EXAMPLE AREA MODELING RESULTS

The ANLCDM dispersion model was used to perform the lead air quality analysis for the example region. ANLCDM is a version of CDMQC using an improved algorithm for calculating area source contributions.

Based on the 1975 inventory, an initial run of the model was used to develop a calibration. A scatterplot of the data is shown in Fig. 5.1. Linear regression with two parameters yielded a regression line

$$\chi_{obs} = 0.46\chi_{calc} + 0.58 \tag{5.1}$$

and a correlation coefficient $r = 0.315$ ($r^2 = 0.0992$). The correlation coefficient r was significant at the 5% level but the regression explained only about 10% of the variation in the data. It should be noted, however, that ANLCDM, like CDMQC, does not treat deposition, fallout, or resuspension and there are a number of uncertainties in the analysis. In such situations attempts would have to be made to validate the model by the procedures listed in Ref. 31. Resources for extensive validation were not available, so the model was used in an uncalibrated form for most of the analysis. The tabulated values that follow, however, can easily be converted to calibrated values by applying Eq. 5.1 after subtracting the 0.15 μg/m³ background from the listed noncalibrated values.

Figures 5.2 and 5.3 illustrate the uncalibrated modeled lead air quality in 1975 and 1982, respectively. In these two figures, calibrated air quality concentrations have been indicated in parentheses following the uncalibrated values. These isopleths were plotted using a computerized plotting routine to interpolate between lead concentrations calculated at the 400 receptor points shown in Fig. 5.4. This receptor network contains a large number of points; states would not normally be expected to calculate air quality at such a large number of points. Tables 5.1 and 5.2 present the computed air quality values at each of the receptor points in Fig. 5.4 for

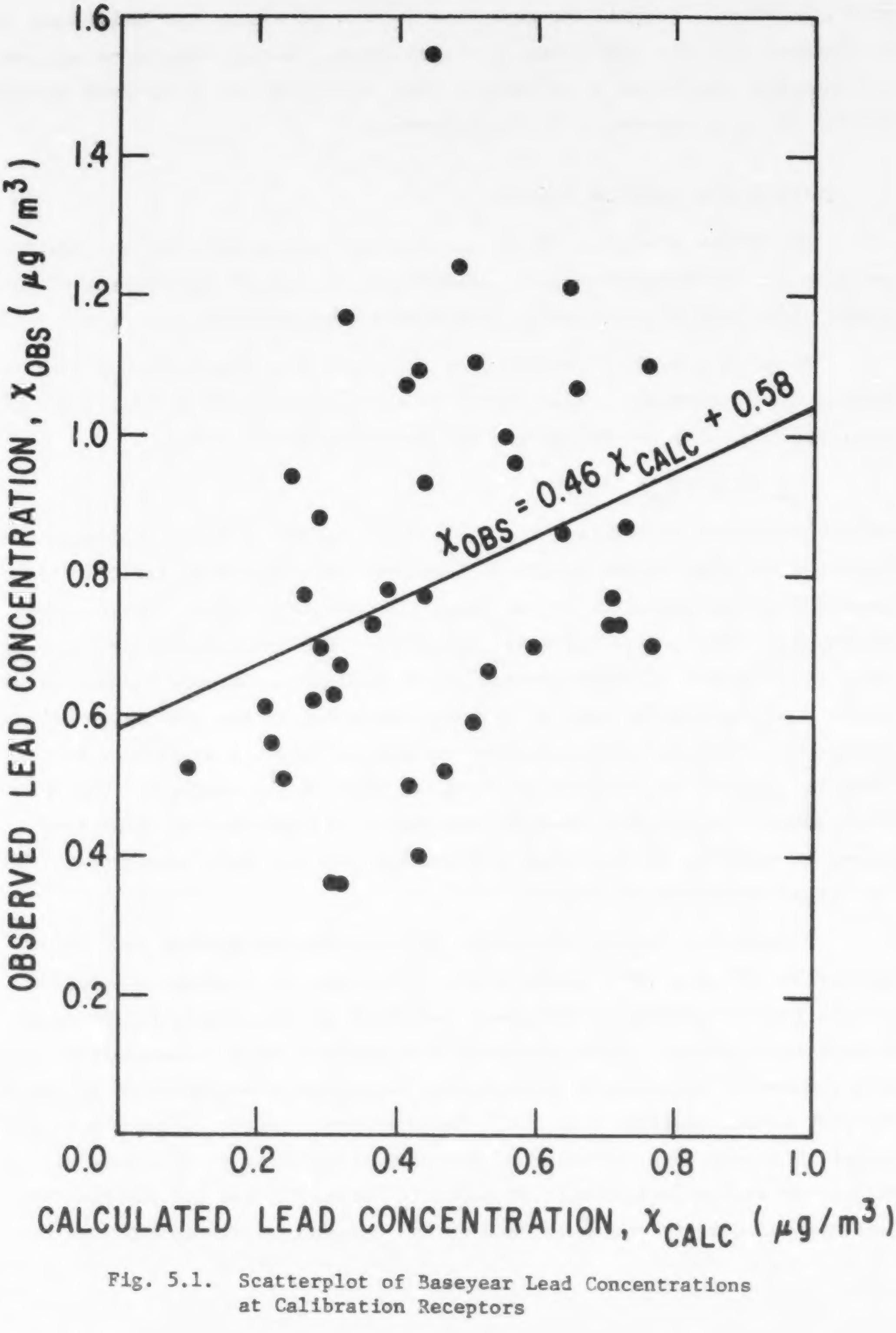

Fig. 5.1. Scatterplot of Baseyear Lead Concentrations at Calibration Receptors

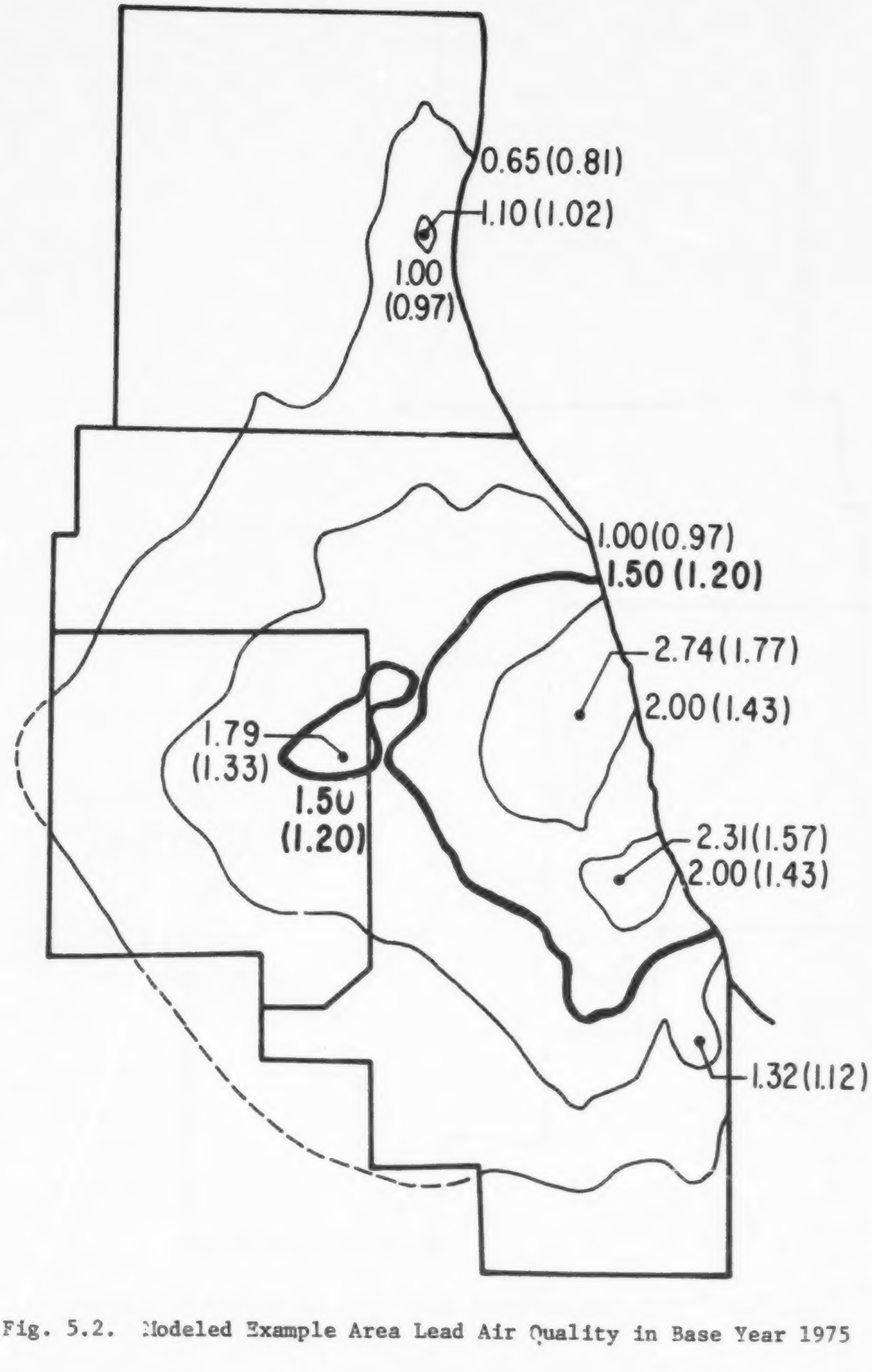

Fig. 5.2. Modeled Example Area Lead Air Quality in Base Year 1975

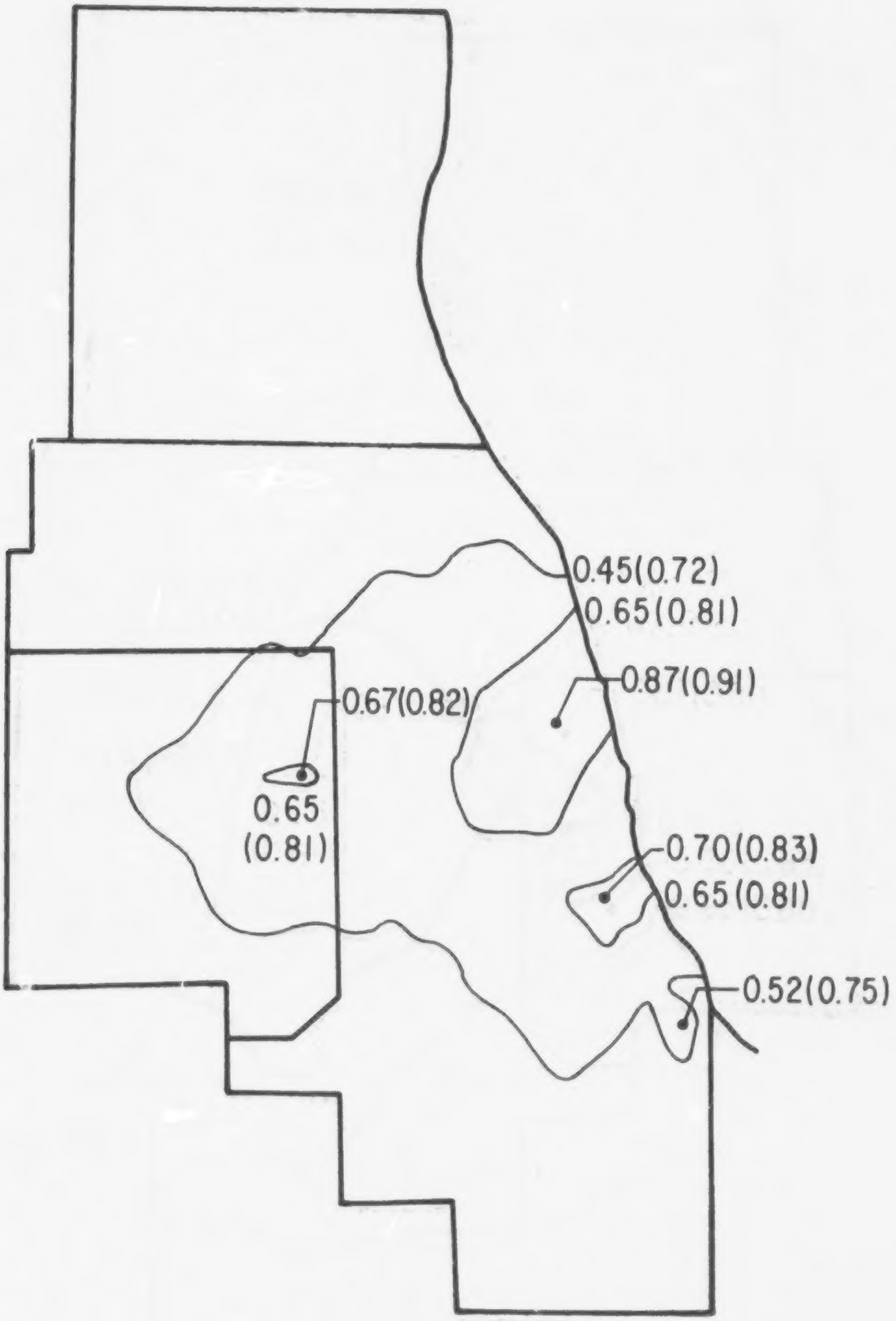

Fig. 5.3. Projected Example Area Lead Air Quality in 1982

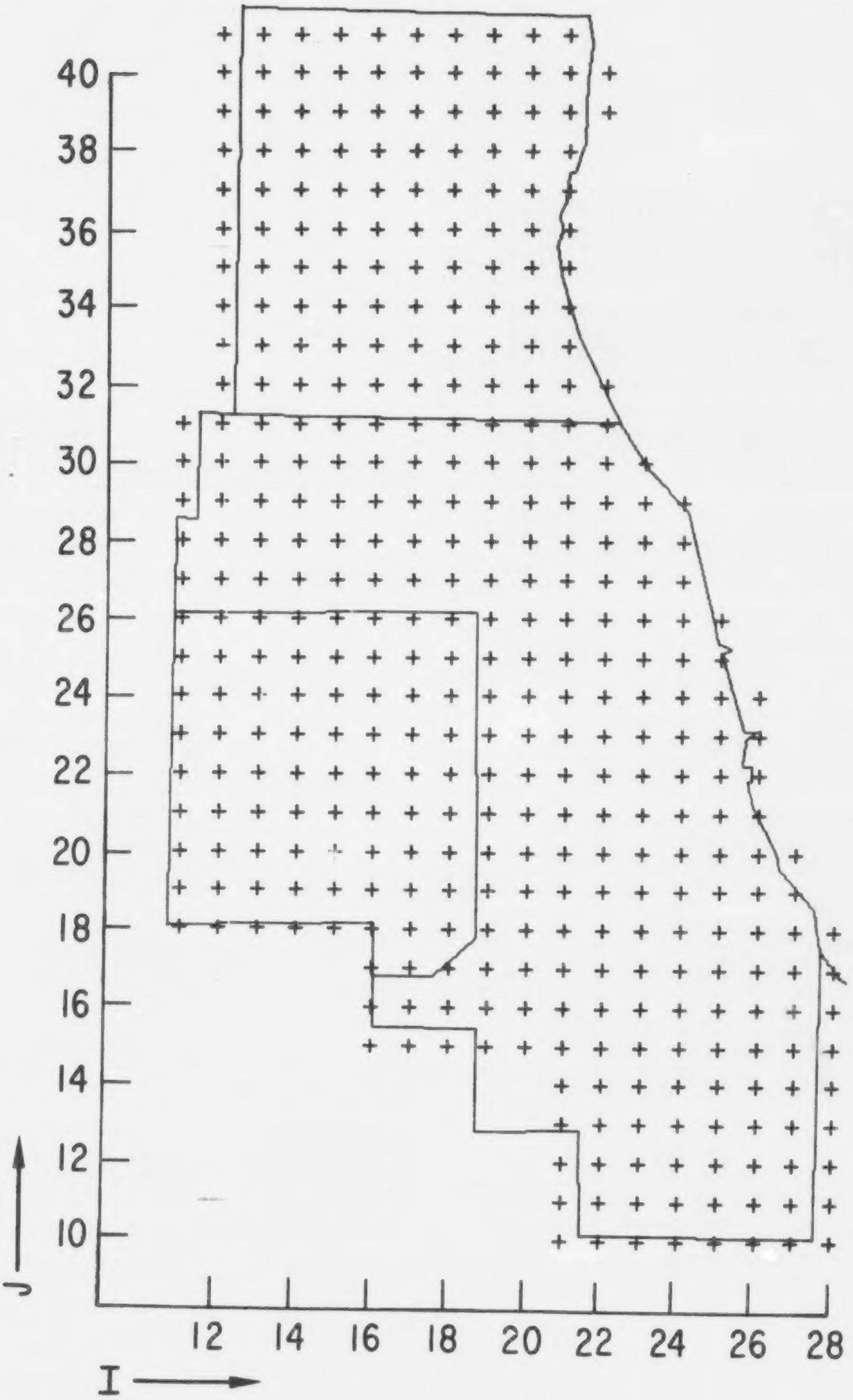

Fig. 5.4. Air Quality Model Receptor Network

Table 5.1 Base-Year (1975) Modeled Lead Concentrations[a]

I =	11	12	13	14	15	16	17	18	19	20
J = 40	0.0	3.1528E-01	3.6354E-01	3.9528E-01	4.2190E-01	4.2890E-01	4.2817E-01	4.4243E-01	4.7406E-01	5.9148E-01
J = 39	0.0	3.3061E-01	3.9318E-01	4.3033E-01	4.5220E-01	4.6050E-01	4.7110E-01	4.8913E-01	5.2753E-01	6.8667E-01
J = 38	0.0	3.4117E-01	4.1055E-01	5.0090E-01	5.0484E-01	4.9983E-01	5.0436E-01	5.3217E-01	6.0803E-01	9.1098E-01
J = 37	0.0	3.4755E-01	4.1473E-01	4.5926E-01	4.8332E-01	4.9622E-01	5.2001E-01	5.6709E-01	6.4013E-01	9.1639E-01
J = 36	0.0	3.5306E-01	4.1324E-01	4.4357E-01	4.6720E-01	4.9431E-01	5.3632E-01	5.[illegible]332E-01	6.8836E-01	1.1031E 00
J = 35	0.0	3.6069E-01	4.2145E-01	4.4935E-01	4.7476E-01	5.0987E-01	6.0087E-01	5.9835E-01	6.6633E-01	7.2632E-01
J = 34	0.0	3.7569E-01	4.3071E-01	4.5496E-01	4.9148E-01	5.5848E-01	6.3056E-01	6.1349E-01	7.0986E-01	7.1697E-01
J = 33	0.0	3.9532E-01	4.5049E-01	4.7548E-01	5.0121E-01	6.0738E-01	5.9865E-01	6.3397E-01	7.3185E-01	7.4724E-01
J = 32	0.0	4.2220E-01	4.7502E-01	5.0175E-01	5.4076E-01	6.6053E-01	6.2617E-01	6.7609E-01	7.3314E-01	8.6158E-01
J = 31	4.1472E-01	4.5623E-01	4.9263E-01	5.4002E-01	6.0132E-01	7.3305E-01	7.2585E-01	7.2535E-01	8.0290E-01	9.3751E-01
J = 30	4.4288E-01	4.8379E-01	5.2074E-01	5.8673E-01	6.7224E-01	7.7418E-01	8.2489E-01	8.4527E-01	9.2049E-01	9.9116E-01
J = 29	4.8285E-01	5.3331E-01	5.7126E-01	6.3078E-01	6.9197E-01	8.4243E-01	9.7649E-01	9.6835E-01	1.0082E 00	1.1180E 00
J = 28	5.2886E-01	5.9636E-01	6.5343E-01	7.1810E-01	7.2795F-01	8.3453E-01	9.5589E-01	1.1135E 00	1.1730E 00	1.2103E 00
J = 27	5.7138E-01	6.2860E-01	7.0250E-01	7.7143E-01	7.7228E-01	8.6017E-01	9.3428E-01	1.0410E 00	1.2349E 00	1.3220E 00
J = 26	5.8858E-01	6.5486E-01	7.2378E-01	8.0843E-01	9.3999E-01	1.0286E 00	1.1473E 00	1.1132E 00	1.3675E 00	1.3399E 00
J = 25	6.4388E-01	6.6815E-01	7.3060E-01	8.3702E-01	9.4333E-01	1.1149E 00	1.2462E 00	1.3761E 00	1.6180E 00	1.4863E 00
J = 24	6.7758E-01	7.3545E-01	7.8300E-01	9.1718E-01	1.0454E 00	1.1641E 00	1.4146E 00	1.5949E 00	1.4297E 00	1.4860E 00
J = 23	7.3011E-01	8.2273E-01	8.8875E-01	1.1224E 00	1.3488E 00	1.3669E 00	1.7065E 00	1.7899E 00	1.4850E 00	1.6732E 00
J = 22	8.7341E-01	7.7838E-01	8.6465E-01	1.0592E 00	1.1500E 00	1.2531E 00	1.2444E 00	1.2257E 00	1.2781E 00	1.4807E 00
J = 21	6.4398E-01	7.0806E-01	7.9117E-01	9.3459E-01	1.0167E 00	1.1746E 00	1.2538E 00	1.2805E 00	1.3109E 00	1.4459E 00
J = 20	6.1537E-01	6.7191E-01	7.4951E-01	8.8365E-01	9.8251E-01	1.1042E 00	1.2511E 00	1.1802E 00	1.3881E 00	1.1865E 00
J = 19	5.9002E-01	6.4014E-01	7.0554E-01	8.3207E-01	9.0420E-01	9.5617E-01	9.7466E-01	9.0044E-01	1.1372E 00	1.0597E 00
J = 18	5.2772E-01	5.6859E-01	6.1528E-01	6.6487E-01	7.1288E-01	7.6545E-01	8.1069E-01	8.9183E-01	8.4903E-01	9.6678E-01
J = 17	0.0	0.0	0.0	0.0	0.0	6.6469E-01	7.4071E-01	7.3573E-01	7.6990E-01	8.5893E-01
J = 16	0.0	0.0	0.0	0.0	0.0	5.9955E-01	6.5239E-01	6.5570E-01	7.0337E-01	7.7653E-01
J = 15	0.0	0.0	0.0	0.0	0.0	5.4439E-01	5.5968E-01	5.9162E-01	6.4498E-01	6.8667E-01
J = 14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J = 13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J = 12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J = 11	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J = 10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

I =	21	22	23	24	25	26	27	28
J = 40	6.1085E-01	4.1901E-01	0.0	0.0	0.0	0.0	0.0	0.0
J = 39	5.9811E-01	4.3389E-01	0.0	0.0	0.0	0.0	0.0	0.0
J = 38	6.7365E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J = 37	6.4839E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J = 36	6.1798E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J = 35	6.0976E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J = 34	6.6334E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J = 33	8.1611E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J = 32	8.9104E-01	6.9590E-01	0.0	0.0	0.0	0.0	0.0	0.0
J = 31	8.3679E-01	8.0328E-01	0.0	0.0	0.0	0.0	0.0	0.0
J = 30	8.8458E-01	9.8231E-01	8.6959E-01	0.0	0.0	0.0	0.0	0.0
J = 29	1.0203E 00	1.1511E 00	1.1374E 00	8.8099E-01	0.0	0.0	0.0	0.0
J = 28	1.1816E 00	1.3384E 00	1.4398E 00	1.1726E 00	0.0	0.0	0.0	0.0
J = 27	1.4058E 00	1.5633E 00	1.5697E 00	1.8931E 00	0.0	0.0	0.0	0.0
J = 26	1.5332E 00	1.6577E 00	1.9325E 00	2.2381E 00	1.3164E 00	0.0	0.0	0.0
J = 25	1.7926E 00	2.0453E 00	2.2382E 00	2.2777E 00	2.3724E 00	0.0	0.0	0.0
J = 24	1.8081E 00	2.0929E 00	2.4439E 00	2.7377E 00	2.1943E 00	1.1332E 00	0.0	0.0
J = 23	1.7843E 00	2.2533E 00	2.5180E 00	2.4454E 00	1.7447E 00	1.1568E 00	0.0	0.0
J = 22	1.6249E 00	2.0972E 00	2.3485E 00	2.1092E 00	1.7662E 00	1.2701E 00	0.0	0.0
J = 21	1.5559E 00	1.5781E 00	1.6340E 00	1.9502E 00	1.8671E 00	2.2629E 00	0.0	0.0
J = 20	1.4854E 00	1.6559E 00	1.7545E 00	2.0204E 00	2.3148E 00	2.1786E 00	1.1843E 00	0.0
J = 19	1.1967E 00	1.3051E 00	1.5050E 00	1.7466E 00	2.1454E 00	1.9168E 00	1.6399E 00	0.0
J = 18	1.1300E 00	1.2861E 00	1.4273E 00	1.5271E 00	1.7007E 00	1.3918E 00	1.1679E 00	7.9565E-01
J = 17	9.3900E-01	1.0819E 00	1.2717E 00	1.5942E 00	1.5489E 00	1.0357E 00	1.0359E 00	6.9952E-01
J = 16	8.4852E-01	9.5441E-01	1.0803E 00	1.4088E 00	1.1638E 00	9.5844E-01	1.3154E 00	6.3192E-01
J = 15	7.3527E-01	8.1822E-01	9.9799E-01	1.0408E 00	1.0134E 00	9.1178E-01	8.3657E-01	5.8112E-01
J = 14	6.7318E-01	7.6540E-01	9.1319E-01	9.8945E-01	7.8012E-01	7.9291E-01	7.9408E-01	5.1917E-01
J = 13	6.0576E-01	6.6789E-01	7.0255E-01	7.1620E-01	6.5166E-01	6.4313E-01	7.7086E-01	4.7637E-01
J = 12	5.3576E-01	5.6788E-01	5.9456E-01	6.3950E-01	6.1819E-01	5.2860E-01	5.2385E-01	4.0219E-01
J = 11	4.9424E-01	5.1742E-01	5.4961E-01	6.3632E-01	6.0884E-01	4.6175E-01	4.5891E-01	3.5876E-01
J = 10	4.4688E-01	4.4741E-01	4.5254E-01	4.2633E-01	4.0855E-01	3.6834E-01	3.3874E-01	3.2528E-01

[a] The location of the receptors (I,J) is shown in Fig. 5.4.

Table 5.2 Projected (1982) Modeled Lead Concentrations[a]

I =	11	12	13	14	15	16	17	18	19	20
J = 40	0.0	2.0369E-01	2.2061E-01	2.3179E-01	2.4080E-01	2.4181E-01	2.3633E-01	2.3959E-01	2.5322E-01	3.0381E-01
J = 39	0.0	2.1020E-01	2.3392E-01	2.4586E-01	2.5266E-01	2.5406E-01	2.5612E-01	2.6186E-01	2.7735E-01	3.4199E-01
J = 38	0.0	2.1486E-01	2.4070E-01	2.7410E-01	2.7364E-01	2.6982E-01	2.6888E-01	2.7916E-01	3.1019E-01	4.3660E-01
J = 37	0.0	2.1733E-01	2.4191E-01	2.5636E-01	2.6339E-01	2.6730E-01	2.7353E-01	2.9013E-01	3.2000E-01	4.3597E-01
J = 36	0.0	2.1827E-01	2.3959E-01	2.4832E-01	2.5449E-01	2.6343E-01	2.7677E-01	2.9644E-01	3.3151E-01	4.4931E-01
J = 35	0.0	2.2042E-01	2.4169E-01	2.4952E-01	2.5677E-01	2.6667E-01	2.9925E-01	2.9591E-01	3.2040E-01	3.3517E-01
J = 34	0.0	2.2426E-01	2.4410E-01	2.5070E-01	2.6070E-01	2.7524E-01	3.0580E-01	2.9978E-01	3.2651E-01	3.2992E-01
J = 33	0.0	2.3063E-01	2.5017E-01	2.5719E-01	2.6268E-01	2.8314E-01	2.8761E-01	3.0397E-01	3.3088E-01	3.4029E-01
J = 32	0.0	2.4033E-01	2.5963E-01	2.6748E-01	2.7368E-01	2.9758E-01	2.9654E-01	3.1254E-01	3.4529E-01	3.7931E-01
J = 31	2.3683E-01	2.6123E-01	2.7414E-01	2.7972E-01	2.9203E-01	3.2070E-01	3.1934E-01	3.2221E-01	3.4365E-01	3.8241E-01
J = 30	2.4535E-01	2.7019E-01	2.8247E-01	2.9195E-01	3.0969E-01	3.3301E-01	3.4414E-01	3.4777E-01	3.6591E-01	3.8572E-01
J = 29	2.6026E-01	2.7968E-01	2.9230E-01	3.0357E-01	3.1831E-01	3.5113E-01	3.8172E-01	3.8102E-01	3.8912E-01	4.0914E-01
J = 28	2.7329E-01	2.9205E-01	3.0806E-01	3.2396E-01	3.3022E-01	3.5421E-01	3.8329E-01	4.1969E-01	4.3462E-01	4.4506E-01
J = 27	2.8922E-01	3.0819E-01	3.2627E-01	3.4174E-01	3.4616E-01	3.6592E-01	3.8517E-01	4.1158E-01	4.5816E-01	4.8623E-01
J = 26	3.3415E-01	3.5893E-01	3.6858E-01	3.7582E-01	4.0836E-01	4.3187E-01	4.8653E-01	4.5833E-01	4.9308E-01	4.8509E-01
J = 25	3.4011E-01	3.6218E-01	3.7526E-01	3.8691E-01	4.1287E-01	4.6041E-01	4.9767E-01	5.2734E-01	5.5258E-01	5.1460E-01
J = 24	3.4916E-01	3.8187E-01	3.8751E-01	4.1083E-01	4.4770E-01	4.8316E-01	5.5978E-01	6.0228E-01	5.1535E-01	5.2112E-01
J = 23	3.5245E-01	3.8469E-01	4.0347E-01	4.7810E-01	5.5422E-01	5.5375E-01	6.5741E-01	6.7483E-01	5.3193E-01	5.6843E-01
J = 22	3.8376E-01	3.7529E-01	3.9817E-01	4.5048E-01	4.7775E-01	5.1208E-01	5.0715E-01	4.8900E-01	4.7845E-01	5.2081E-01
J = 21	3.3489E-01	3.5731E-01	3.7969E-01	4.1598E-01	4.4060E-01	4.9377E-01	5.1551E-01	5.1471E-01	4.8933E-01	5.2541E-01
J = 20	3.2716E-01	3.4739E-01	3.6749E-01	4.0052E-01	4.3175E-01	4.7120E-01	5.1788E-01	4.8247E-01	5.0323E-01	4.6551E-01
J = 19	3.1411E-01	3.3150E-01	3.5220E-01	3.8258E-01	4.0502E-01	4.1967E-01	4.2252E-01	4.1040E-01	4.3767E-01	4.1906E-01
J = 18	2.8789E-01	3.0211E-01	3.1659E-01	3.2380E-01	3.3781E-01	3.5695E-01	3.7297E-01	3.9016E-01	3.7193E-01	3.9903E-01
J = 17	0.0	0.0	0.0	0.0	0.0	3.2702E-01	3.4770E-01	3.4364E-01	3.5227E-01	3.6800E-01
J = 16	0.0	0.0	0.0	0.0	0.0	3.0065E-01	3.1595E-01	3.1665E-01	3.2954E-01	3.4275E-01
J = 15	0.0	0.0	0.0	0.0	0.0	2.7363E-01	2.7707E-01	2.8742E-01	3.0811E-01	3.1721E-01
J = 14	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J = 13	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J = 12	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J = 11	0,0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J = 10	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

I =	21	22	23	24	25	26	27	28
J = 40	3.1522E-01	2.4067E-01	0.0	0.0	0.0	0.0	0.0	0.0
J = 39	3.1017E-01	2.4451E-01	0.0	0.0	0.0	0.0	0.0	0.0
J = 38	3.4044E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J = 37	3.2130E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J = 36	2.9858E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J = 35	2.9501E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J = 34	3.1105E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J = 33	3.0646E-01	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J = 32	3.9189E-01	3.1797E-01	0.0	0.0	0.0	0.0	0.0	0.0
J = 31	3.5798E-01	3.4297E-01	0.0	0.0	0.0	0.0	0.0	0.0
J = 30	3.5904E-01	3.7741E-01	3.7277E-01	0.0	0.0	0.0	0.0	0.0
J = 29	3.9417E-01	4.2069E-01	4.2377E-01	3.5576E-01	0.0	0.0	0.0	0.0
J = 28	4.3485E-01	4.9137E-01	4.9266E-01	4.2688E-01	0.0	0.0	0.0	0.0
J = 27	5.0161E-01	6.3563E-01	5.3337E-01	6.1666E-01	0.0	0.0	0.0	0.0
J = 26	5.4080E-01	5.5542E-01	6.2625E-01	7.1355E-01	4.7092E-01	0.0	0.0	0.0
J = 25	5.9626E-01	6.4814E-01	7.0254E-01	7.1604E-01	7.5517E-01	0.0	0.0	0.0
J = 24	5.9508E-01	6.6260E-01	7.5783E-01	8.6932E-01	7.1052E-01	4.1854E-01	0.0	0.0
J = 23	5.9299E-01	7.1633E-01	8.0674E-01	7.4977E-01	5.8037E-01	4.2243E-01	0.0	0.0
J = 22	5.5503E-01	6.8217E-01	7.2363E-01	6.6445E-01	5.7425E-01	4.4646E-01	0.0	0.0
J = 21	5.7800E-01	5.4922E-01	5.4818E-01	6.2683E-01	5.9598E-01	6.8909E-01	0.0	0.0
J = 20	5.9253E-01	5.7660E-01	5.8042E-01	6.4057E-01	7.0240E-01	6.7264E-01	4.2472E-01	0.0
J = 19	4.4700E-01	4.6586E-01	5.1319E-01	5.6897E-01	6.6057E-01	6.1419E-01	5.4493E-01	0.0
J = 18	4.2115E-01	4.5739E-01	4.9027E-01	5.2372E-01	5.3456E-01	4.7867E-01	4.3044E-01	3.3246E-01
J = 17	3.7805E-01	4.0791E-01	4.5602E-01	5.3864E-01	5.3343E-01	4.1012E-01	5.2080E-01	3.0361E-01
J = 16	3.5157E-01	3.7234E-01	4.0393E-01	4.7941E-01	4.3108E-01	3.7364E-01	4.4210E-01	2.8479E-01
J = 15	3.2485E-01	3.3747E-01	3.7799E-01	3.8858E-01	3.8529E-01	3.5489E-01	3.8112E-01	2.6679E-01
J = 14	3.0533E-01	3.2137E-01	3.3223E-01	3.6949E-01	3.2004E-01	3.2102E-01	3.0668E-01	2.4998E-01
J = 13	2.8045E-01	2.9760E-01	3.0356E-01	3.0438E-01	2.8795E-01	2.8054E-01	2.8873E-01	2.3543E-01
J = 12	2.6028E-01	2.7548E-01	2.8095E-01	2.8545E-01	2.7921E-01	2.5555E-01	2.5270E-01	2.2061E-01
J = 11	2.4865E-01	2.6162E-01	2.6720E-01	2.8226E-01	2.7553E-01	2.3890E-01	2.3774E-01	2.1035E-01
J = 10	2.3528E-01	2.3938E-01	2.3770E-01	2.2982E-01	2.2345E-01	2.1141E-01	2.0659E-01	2.0131E-01

[a] The location of the receptors (I,J) is shown in Fig. 5.4.

1975 and 1980, respectively. In making these computations, it was assumed that no new control programs were in force, only existing state programs, federal NSPS, and the federal programs for the reduction of the lead content of gasoline and improved fuel economy were assumed to be in effect.

Figure 5.2 shows several areas exceeding the lead NAAQS in 1975. Despite growth and development and increased vehicular travel, Fig. 5.3 shows compliance with the lead NAAQS in 1982. This conclusion remains the same regardless of whether the calibrated or uncalibrated air quality values are used. The improvement in air quality between 1975 and 1990 is due almost entirely to the reduction in emissions from highway vehicles as was noted above in Sec. 3.3. This reduction in emissions results from the federal programs for the reduction of the lead content of gasoline and improved fuel economy.

6 ANALYSIS OF MODELING RESULTS

6.1 GENERAL

The analysis of modeling results is outlined fairly thoroughly in Ref. 16 which discusses four basic considerations involved in such an analysis:

- The magnitude of the problem,
- The geographical extent of the problem,
- The temporal extent of the problem, and
- The identification of sources contributing to the problem.

The guidance presented in Ref. 16 emphasizes point sources and the use of dispersion models. Little need be added to that guidance to account for lead except to add several comments concerning area sources and the use of modified rollback.

Area Sources

As noted in the development of the emission inventory, highway vehicles may be the predominant source of lead emissions in some areas. It is thus important to be able to assess the contribution of this source category in analyzing modeling results and developing control strategies. Highway vehicle emissions will almost always be treated as part of the area source emission rates in dispersion models. However, the dispersion models recommended for use in Sec. 5[17,31] give at most the contribution of each individual area source, of which the allocated highway vehicle emissions are one component, to the concentration at a given point. (This problem will be eliminated with the publication of the Industrial Source Complex Model and the PBLSQ model.) A more useful piece of information might be the total contribution of the individual area source categories to the concentration, since regulations are generally developed to cover entire area source categories. The category-specific contributions can be found by making multiple model runs with a model which gives an area source culpability list. Each run would be made with an emission inventory consisting of the allocated emissions from the area source category whose contributions were desired. The sum over all area sources of the individual area source contributions at each receptor of interest would then give the total contribution from the category at these receptors. If the use of this technique is contemplated, care should be taken during emission allocation to tabulate the emissions separately for those categories whose individual contributions are likely to be desired. Also, since multiple model runs are required, the categories should be chosen judiciously to avoid the use of a large amount of computer resources. States might also want to consider developing computerized routines to produce culpability lists for specific area source categories for use with their dispersion models. If neither of these suggestions appears viable, the area source emission inventory can be examined to determine the largest emitting categories. These are likely to be the largest contributors to problems caused by area sources and hence should be the initial categories selected for control during strategy development. This last method relies only on total emissions and neglects the effects of allocation and dispersion. It is thus likely to be less precise than developing category-specific contributions using a dispersion model.

Modified Rollback

Modified rollback need only be used in the vicinity of monitors exceeding the lead NAAQS unless a monitor exceeds 4.0 $\mu g/m^3$, quarterly average, in which case attainment must be demonstrated in the entire urbanized area using modified rollback as a minimum [51.83 and 51.85]. If one of the forms of modified rollback which allocates the emissions to grid cells is used, the projected changes in air quality apply only at the central point of the emission grids. Thus, in areas with only a few lead monitors, an assessment of the overall magnitude, geographical extent, and temporal extent of the lead problem is likely to be inaccurate. This situation is not unexpected given the approximations made in the modified rollback models and it is still within the spirit of these approximations to make these assessments to the degree possible in analyzing the results of modified rollback.

It is possible to estimate the concentration contributions of individual source categories using modified rollback. An example illustrating the technique is given in Refs. 17 and 30. In general, all forms of modified rollback can be derived from Eq. 34 in Ref. 30:

$$\frac{(c_i - b)}{(c_{max-base} - b)} = \Sigma[(wf_j)_{base} \times gf_j \times ef_j] \qquad (6.1)$$

where c_i is the projected concentration and wf_j is proportional to the emissions in the j^{th} source category. Thus, by keeping track of the various terms in the sum, the contributions of the source categories j to the concentration c_i can be determined.

6.2 ILLUSTRATION FROM EXAMPLE AREA

The modeling results presented at the end of Sec. 5 indicate that the lead NAAQS will be attained in 1982 and hence that no extension will be required. Furthermore, no additional strategies beyond those already in effect will be required. It should be noted that the modeled point source contributions used in developing the air quality information in Table 5.2 and Fig. 5.3 are conservative in that they do not include the impact of reasonably available control technology (RACT) for particulates which will be required as part of the example area's nonattainment SIP revision. The uncalibrated hot spot in Table 5.2 is only 0.87 $\mu g/m^3$ which corresponds to a calibrated value of 0.91 $\mu g/m^3$. Both values are well below the 1.5 $\mu g/m^3$ NAAQS. Since the meteorological data used appeared to be the worst available from an air quality perspective, there is little doubt that the lead NAAQS will be attained.

Had there been NAAQS violations in 1982, it would have been necessary to identify the sources contributing to the air quality problem. ANLCDM provides the source contributions for both point and area sources. The model was used in a way which allowed the determination of the contributions of individual area source categories rather than the contributions of individual area sources to air quality at a given receptor. Table 6.1 presents a summary of such results for receptor 297 (I = 22, J = 27) in 1982. In the table, area sources have been placed in groups; the same allocation parameter has been used for each group. Except for allocation by UTM coordinates, comparison of the total emissions from each source category within a group with the total emissions from the group will accurately reflect the individual category's contribution to the air quality. For example, Table 3.5 shows that the 1985 emissions for the first group of area sources in Table 6.1 are projected to be:

Table 6.1 Sample Source Contribution Analysis for Example Area[a]

Source Category	Quarterly Lead Concentration ($\mu g/m^3$)	Percentage of Total Concentration
Major Point		
A	0.000	0.05
B	0.081	12.69
C	0.000	0.02
D	0.000	0.02
E	0.000	0.01
F	0.000	0.00
G	0.000	0.00
H	0.000	0.01
I	0.000	0.01
J	0.000	0.00
K	0.000	0.00
L	0.000	0.05
M	0.000	0.01
N	0.000	0.01
O	0.000	0.00
Area		
Commercial/Institutional fuel combustion, industrial fuel combustion, incineration, and arterial roads[b]	0.193	30.31
Freeways	0.039	6.07
Residential fuel combustion	0.082	12.85
"Residual" points and industrial fugitives	0.079	12.50
Other	0.011	1.77
Background	0.150	23.60
TOTAL	0.64	100

[a] At receptor 295 (I = 22, J = 27).

[b] The quarterly lead concentration due to arterial roads is 0.127 $\mu g/m^3$. Similarly, the air quality contribution of each individual area source category can be determined by proportion as discussed in the text on pp. 79 and 81. However, the contributions of individual "residual" points cannot be determined by this method.

Industrial Fuel Combustion	0.7368 tons/yr
Commercial/Institutional Fuel Combustion	6.7273
Arterial Roads	620.6600
Incineration (Solid Waste Disposal)	314.8500
Total 1985 Lead Emissions	942.9741 tons/yr

Thus, arterial roads account for (620.66/942.9741) × 100 = 65.82% of the 1985 emissions from the group. Since all source categories in the group were allocated to the model's emission grid using population as an allocation parameter (see Table 4.1), arterial roads would also account for 65.82% of the group's air quality contribution at any receptor. For receptor 297:

Air quality contribution from arterial roads

$= .193 \times .6582 = 0.127\ \mu g/m^3$ lead, quarterly average.

Although this receptor is not the area-wide hot spot, it is close to the hot spot located at I = 24, J = 24. Based on this receptor and the relative magnitudes of the emissions given in Table 3.5, vehicles, residential fuel combustion, and industrial process fugitives would be the most likely candidates for additional control if there were a lead problem. The potential for additional control at Plant B would also need to be investigated. In actual practice, these initial indications would need to be evaluated further and modified, if necessary, by examing the regional hot spot itself and the other local hot spots in the example area.

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7 SELECTION, TESTING, AND EVALUATION OF STRATEGIES

A fairly complete discussion of the methods for selecting, testing, and evaluating control strategies is available in Ref. 16. Since additional controls beyond those already contemplated do not appear to be required for attainment of the lead NAAQS in the example area, this discussion is limited to a lead-specific amplification of the material in Ref. 16 and no illustrative material from the example region is included.

7.1 AVAILABLE STRATEGIES

Reference 16 discusses both technological and land use and planning controls. The technological strategies include:

- New Source Performance Standards (NSPS),
- Existing source retrofit,
- Phase-out of emission sources,
- Fuel conversion,
- Energy conservation,
- Combination of emission sources, and
- Fugitive dust controls.

It should be noted that special operating conditions or supplementary control systems (SCS) are suggested as a potential strategy for short-term standards in Ref. 16. Given that there is currently no short-term lead standard and the current Clean Air Act requirements that emission control systems operate continuously,[46] SCS need not be considered as a lead control strategy. Also, since the recognition of the energy crisis, fuel conversions can probably not be used as a control technique in most situations. In fact, fuel conversions are most likely to be from scarce clean fuels to more abundant dirty fuels giving an emission increase as discussed in the example in Sec. 3.1.2.

Land use and planning measures are summarized in Tables 8-1 and 8-2 of Ref. 16 and discussed in the accompanying text. States desiring to investigate these types of strategies should consult the reference. The measures listed there could be applied to lead.

Given the large amount of process fugitive emissions likely to be associated with lead point sources, recent legislative and regulatory requirements, and the large amount of emissions associated with vehicular sources, states may want to consider several other options in developing lead strategies. These include:

- Industrial fugitive emission controls,
- Reasonably Available Control Technology (RACT), Best Available Control Technology (BACT), or Lowest Achieveable Emission Rate (LAER) controls,
- Limitations on the lead content of gasoline more stringent than the federal limitations,
- Transportation control measures, and
- Retrofit of vehicles with lead traps (particulate collection devices).

Fugitive emissions are expected to be significant around several significant lead point sources such as primary and secondary lead smelters and primary copper smelters. In general, the whole subject of industrial fugitive emissions is currently under intensive investigation.[47,48,49] The information in these references pertains to particulates, but could potentially be revised to account for lead in cases where the source types covered are contributing to the lead problem.

The generic control technologies listed above are required by other federal programs. RACT applies to retrofit controls on existing sources; BACT and LAER are new source controls and must be at least as stringent as NSPS.[46,50] EPA has established a clearinghouse for information on determinations for these technologies. As an aid in setting control requirements, states considering either stringent retrofit controls or very stringent controls for new sources may want to check with the EPA Regional Office for the latest particulate information available from the clearinghouse.

In Sec. 211(c)(4)(C), the Clean Air Act provides that states may impose limitations on the lead content of gasoline more stringent than the federal requirements. This strategy can be considered as an alternative to vehicle use constraints in areas where the existing federal program and stationary source controls fail to provide for a demonstration of attainment of the lead NAAQS within the mandated time. This strategy may present substantial administrative and enforcement problems and requires approval by the EPA Administrator.

Since vehicles are frequently a major source of lead emissions, vehicle use constraints provide another set of strategies that may be considered. References 51 and 52 provide a list of such strategies. In particular, Ref. 52 provides a list of reasonable transportation control measures (RTCMs). Not all the strategies listed in these references would be effective for lead so some care should be exercised in selecting candidate strategies for analysis. In addition, vehicular lead emissions can be reduced by the use of land traps as described in Ref. 24.

7.2 SELECTING AND TESTING STRATEGIES

There are too many strategies available to permit an agency to evaluate them all. Reference 16 discusses a screening procedure that can be used to select a set of strategies for detailed analysis. States need not apply this procedure but consultation of Ref. 16 is recommended, because it presents the considerations which are important in selecting the strategies for analysis.

Reference 16 also describes how to model the various strategies it lists. The same procedures can be used for lead. With respect to NSPS, however, it should be noted that additional material is available in Refs. 53, 54, and 55. Updated information on controls applicable to fugitive dust sources is also available in Ref. 56. Control of reentrained road dust is discussed in Ref. 57 and should be applicable to lead. Reference 24 provides information on the control of lead emissions from several source categories including lead traps on highway vehicles. These technological controls would be simulated by modifying either the control efficiency, W, or the emission factor, EF (in the event of process change or modification), in Eqs. 2.1 and 2.3 as discussed in Ref. 16.

Controls on fugitive lead emissions from industrial processes would be simulated by using the appropriate value for W in Eq. 2.1. References 24 and 25 contain information developed specifically for lead fugitives while Refs. 47, 48, and 49 deal with particulates in general. The control information in these three references could be used if lead-specific information is unavailable.

RACT, BACT, and LAER determinations from the clearinghouse could provide useful estimates on available control technologies and efficiencies for both existing and new sources. Some LAER determinations might preclude certain emissive processes so that if LAER-level controls were being contemplated for new/modified sources, the simulation might require changes in both the emission factor, EF, and the control efficiency, W, in Eq. 2.1.

Reduced limitations on the lead content of gasoline can be simulated by using appropriate vales of Pb_n in Eqs. 2.3, 2.4, or 2.5. The value of Pb_n used will depend upon the fraction of vehicles affected and the lead limitations being considered. Appendix C in Ref. 17 discusses the method used to develop the pooled average lead content values used in estimating lead emissions under the current federal program. The method presented there is straightforward and can easily be extended to the case where limitations more stringent than the federal are in effect.

Vehicle use limitations will generally be simulated by changing the average daily traffic (ADT) or vehicle miles travelled (VMT) values in Eqs. 2.3, 2.4, or 2.5 to reflect the effects of the candidate strategy. The Regional Office should be consulted for the latest information on estimating the impacts of these measures; new guidelines are currently being issued and states should attempt to utilize the latest available information. When use of these measures is being considered, the local transportation planning agencies should be involved as early as possible in the lead planning process. These agencies should have valuable insights concerning the effectiveness and ease of implementation of these strategies.

7.3 STRATEGY SELECTION

After the strategies have been selected and modeled, it is quite likely that several strategies or combinations of strategies will be technically acceptable, that is, provide a basis for demonstrating attainment of the lead NAAQS. Additional considerations which may aid in selecting the most appropriate strategies for actual implementation include:[16]

- Economic analysis,
- Social impact analysis, and
- Institutional review.

Regulations do not require either an economic or a social impact analysis. Guidelines for states desiring to do an economic analysis are provided in Appendix D. Additional material is available in Ref. 16 which also provides some assistance in evaluating social impacts.

Certain institutional reviews are required by regulation. Aside from the technical reasons for involving transportation planning agencies when developing vehicle use constraints, the involvement of these agencies is a regulatory requirement.[38,39,40] It is important in an area as complex and sensitive as transportation that all agencies cooperate in the development of consistent and effective plans. Public hearings are required prior to the adoption of any air pollution control regulations.[50] This process and other institutional questions are addressed very briefly in Ref. 16 but neither this work nor the reference is intended to provide specific guidance for this process.

These additional considerations should enable the agency to choose a final set of strategies for implementation. If the analysis has been carried out carefully, the appropriate agencies consulted, and the required comments considered, the plan should be approved with a minimum of difficulty and revision.

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APPENDIX A. BASE-YEAR ACTIVITY LEVELS FOR AREA, FREEWAY, AND ARTERIAL SOURCES

The tables in this appendix do not present the data in its original form. The data in Table A.1 is based on Ref. 58 and includes only the data for those area source categories with lead emissions. Tables A.2 and A.3 present data based on freeway and arterial VMT and speed data for 1,714 traffic zones covering the example area and five nearby counties. These traffic zones are subcounty areas defined for planning and data gathering purposes by the regional transportation agency from which the original VMT data was obtained.

Table A.1 Base-Year (1975) Area Source Activity Levels[a,b]

Source Category	Activity Level (SCC Units/yr) County C	D	L
Residential Fuel Combustion			
Anthracite Coal	4610	10	0
Bituminous Coal	639070	1110	330
Distillate Oil	206630	91410	25120
Commercial/Institutional Fuel Combustion			
Bituminous Coal	16490	1780	770
Distillate Oil	140160	14550	6550
Residual Oil	184540	19970	5840
Industrial Fuel Combustion			
Bituminous Coal	503210	45370	56590
Distillate Oil	140480	13510	17230
Residual Oil	388610	37350	47670
Residential On-Site Incineration	751890	378550	288570
Off-Highway Gasoline Vehicles	22966	21202	1841
Fugitive Dust			
Unpaved Roads	4668	2481	7612
Land Tilling	184	163	193

[a] Only categories with nonzero activity levels are listed. Highway vehicle activity levels are given in Table A.2.

[b] Compiled from Ref. 58.

Table A.2 Example Area Freeway Link Lead Emissions for Base Year 1975[a]

Link No.[b]	Average Vehicle Speed (miles/hr)	VMT/day / 100	Lead Emissions (ton/yr)[c,d]
1A	57.5	3200	5.70
3[c]	52.7	8651	3.94
4A	57.5	12,164	21.3
4B	55.5	8576	14.1
6	50.4	5532	7.88
7A	48.2	14,039	18.8
7B	40.9	8345	9.20
7C	38.9	11,563	12.1
7D	35.9	7578	7.26
8	45.3	5860	7.28
9A	45.6	8613	7.36
9B	55.1	6478	10.5
10A[c]	57.4	3693	2.10
11	54.7	2914	4.69
12A[c]	54.2	7256	5.75
18A[c]	57.1	7536	5.85
18B	43.5	25,733	30.5
19	53.1	26,223	40.3
20	50.5	11,144	15.9
21	48.6	8197	11.1
22A	55.0	5977	9.70
22B	56.3	2202	3.72
23	56.5	416	0.707
24	40.5	26,138	28.2
25	48.1	21,772	28.9
26	51.2	15,110	22.0
27A	37.2	8374	8.33
27B	41.7	13,116	8.75
27C	47.2	15,504	20.3
28	54.1	5596	8.85
29[c]	59.1	1663	1.88
30A	51.9	3812	5.66
30B	54.5	3362	10.3
31A	54.5	16,237	25.7
31B	56.0	20,898	35.0
32	51.3	3124	4.56
33	50A	28,421	40.5

---

[a] Lead emissions are total from passenger, light duty and heavy duty gasoline vehicles.

[b] For location of freeway link in example area see Fig. 2.2.

[c] Lead emissions computed only for that portion of link in example area.

[d] Based on VMT from passenger light-duty and heavy-duty gasoline powered vehicles.

Table A.3 Base-Year (1975) Tailpipe Lead Emissions from Vehicle Activity on Arterial Roads

County	$\frac{\text{VMT/day}}{100}$	Lead Emissions (tons/yr)[a,b]
L	65,543	271
D	94,299	390
C	527,847	2183

[a] Lead emissions calculated from passenger, light-duty, and heavy-duty gasoline powered vehicles.

[b] Calculated using county-level VMT with average speed of 19.6 mph for all vehicles[26] and 70% lead exhausted.

APPENDIX B. EMISSION PROJECTION MODEL*

The model incorporates parameters affected by air quality control strategies and exogenous parameters representing growth and replacement. Alteration of parameter values can be used to simulate various control strategies and permits emissions to be projected in a manner consistent with a chosen strategy. The primary symbols used are listed in Table B.1. Fig. B.1 depicts the model schematically. The figure shows how emissions from a source can be estimated. It is important to realize that the model is applied at the source (or source category) level: each individual source (emitting unit) is assumed to grow and to be replaced at appropriate rates. Such an assumption is clearly incorrect with respect to any individual source, for as time passes a particular source is either still as it was originally or has been totally replaced or new sources have been added; no source is partially replaced and partially new. What the model estimates is the total amount of growth and replacement and the associated emissions over the ensemble of similar sources in the inventory. These estimates are made by considering each source individually. In the aggregate they may be expected to be reasonably representative of the emissions picture but for any specific source they may be inaccurate.

Following Fig. B.1, consider a source category whose level of activity at time t_o is P_o. As time passes, the activity level (i.e., the number of production units produced per year) in this category increases linearly at the rate of GR per year. The total activity level at time t_n is

$$P_n = P_o + P_o \times GR(t_n - t_o) = P_o[1 + GR(t_n - t_o)]. \qquad (B.1)$$

In addition, replacement has taken place linearly at the rate of RR per year. At t_n the amount of existing (original) activity left is

$$P_e = P_o - P_o \times RR(t_n - t_o) = P_o[1 - RR(t_n - t_o)]. \qquad (B.2)$$

It is also assumed that at some time T such that $t_o \leq T \leq t_n$ the policy applicable to new growth and replacement construction changes. The growth in

---

*The development presented here closely parallels that found in Ref. 59.

Table B.1 Primary Symbols Used in Emission Projection Model

Symbol	Meaning	Units
t_o	Base year.	
t_n	Projection year.	
T	Year in which regulation applicable to new/modified sources changes ($t_o \leq T \leq t_n$).	
Q_n	Total source category emissions in t_n.	tons/yr
P_n	Source category activity level or capacity in t_n.	production units/yr
P_o	Source category activity level or capacity in t_o. (Capacity is assumed to be fully utilized in t_o.)	production units/yr
P_{gf}	Source category activity level or capacity in t_n associated with growth between T and t_n.	production units/yr
P_{gi}	Source category activity level or capacity in t_n associated with growth between t_o and T.	production units/yr
P_{ri}	Source category activity level or capacity in t_n associated with replacement between t_o and T.	production units/yr
P_{rf}	Source category activity level or capacity in t_n associated with replacement between T and t_n.	production units/yr
P_e	Source category activity level or capacity associated with existing (original sources in t_n.	production units/yr
EF_{en}	Emission factor for existing sources in t_n.	tons/production unit
Ef_{gi}	Emission factor in t_n for sources which are new/modified in initial period between t_o and T.	tons/production unit
EF_{gf}	Emission factor in t_n for sources which are new/modified in final period between t_n and T.	tons/production unit
RR	Replacement rate per year.	yr^{-1}
GR	Growth rate per year.	yr^{-1}

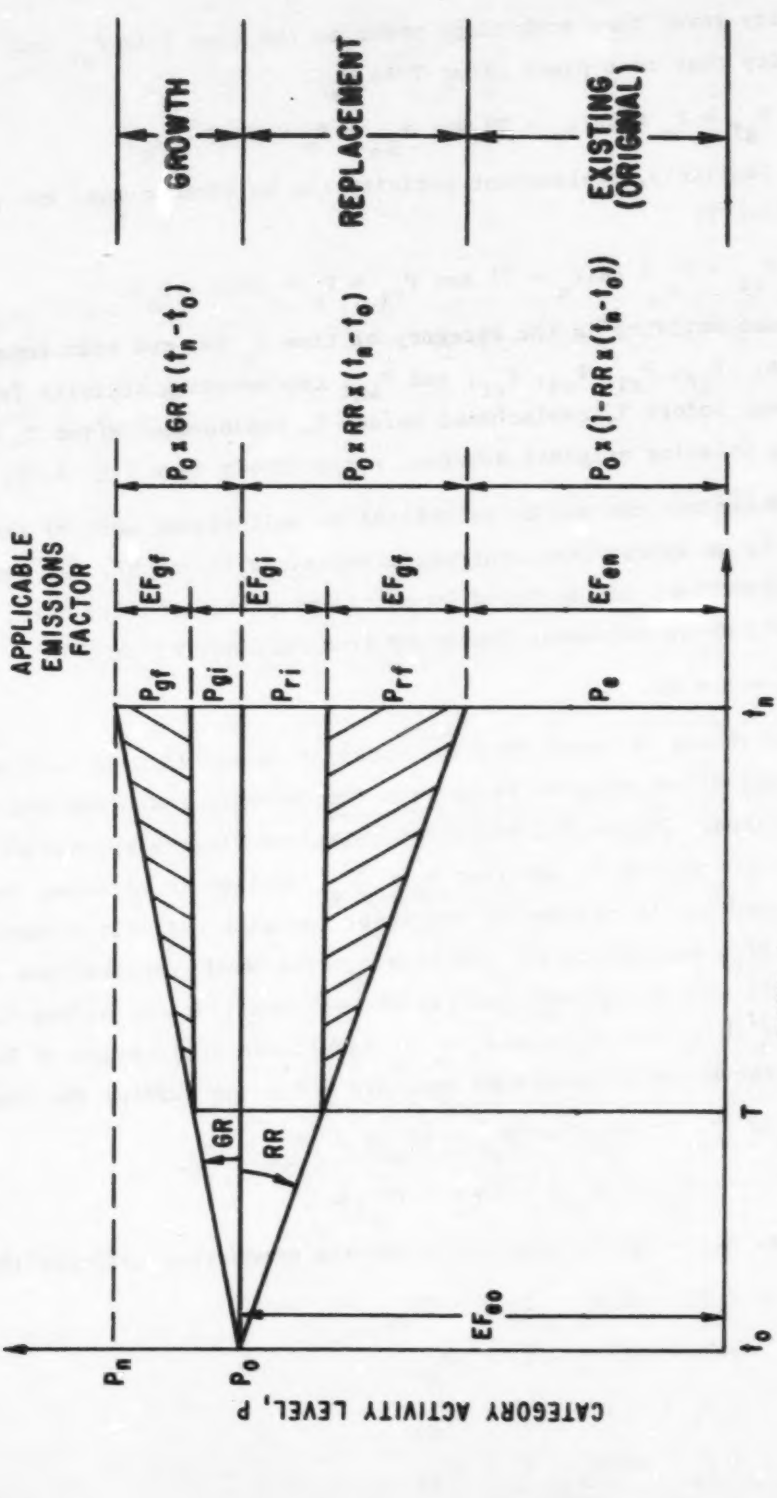
CATEGORY ACTIVITY LEVEL, P
P_n
P_o
t_o
T
t_n
TIME, t
GR
RR
EF_{eo}
APPLICABLE EMISSIONS FACTOR
P_{gf}
P_{gi}
P_{ri}
P_{rf}
P_e
EF_{gf}
EF_{gi}
EF_{gf}
EF_{en}
$P_o \times GR \times (t_n - t_o)$
$P_o \times RR \times (t_n - t_o)$
$P_o \times (1 - RR \times (t_n - t_o))$
GROWTH
REPLACEMENT
EXISTING (ORIGINAL)

Fig. B.1. Emission Projection Model

activity level that took place prior to the time T is P_{gi} and the growth in activity that took place after T is P_{gf}.

$$P_{gf} = P_o \times GR(t_n - T) \text{ and } P_{gi} = P_o \times GR(T - t_o). \tag{B.3}$$

Similarly, replacement activity can be divided into two parts before and after T:

$$P_{rf} = P_o \times RR(t_n - T) \text{ and } P_{ri} = P_o \times RR(T - t_o). \tag{B.4}$$

The total activity in the category at time t_n has now been separated into five classes: P_{gf}, P_{gi}, P_{ri}, P_{rf}, and P_{en}, representing activity from growth since T, growth before T, replacement before T, replacement after T, and the remaining existing original sources, respectively (see Fig. B.1).

Emissions can now be calculated by multiplying each of these activity levels by an appropriate controlled emissions factor EF. In general, emissions Q(tons/yr) can be found by multiplying the activity level (production units/yr) by an emissions factor EF (tons/production unit):

$$Q = P \times EF. \tag{B.5}$$

It should be noted that the emission factor as used here includes both the uncontrolled emission factor and the emission reduction due to any control devices. Figure B.1 shows the emissions factors appropriate to the five classes of activity in the year t_n. EF_{en} applies to existing (original) sources and can be changed to represent changing retrofit control requirements. EF_{gf} applies to all growth and replacement construction since T. EF_{gi} applies to all growth and replacement construction before T. Total emissions in t_n can be calculated by repetitive application of Eq. B.5 to each of the activity levels in Eqs. B.2 - B.4 and summing the results:

$$\begin{aligned} Q_n = {} & [P_{en} \times EF_{en}] + [P_{gf} \times EF_{gf}] + [P_{gi} \times EF_{gi}] \\ & + [P_{rf} \times EF_{gf}] + [P_{ri} \times EF_{gi}]. \end{aligned}$$

Using Eqs. B.2 - B.4 to substitute for the production activity levels:

$$\begin{aligned} Q_n = {} & P_o[1 - RR(t_n - t_o)] \times EF_{en} \\ & + P_o \times GR(t_n - T) \times EF_{gf} \\ & + P_o \times GR(T - t_o) \times EF_{gi} \\ & + P_o \times RR(t_n - T) \times EF_{gf} \end{aligned}$$

$$
\begin{aligned}
&+ P_o \times RR(T - t_o) \times EF_{gi} \\
\text{or } Q_n &= [P_o \times EF_{en}][1 - RR(t_n - t_o)] \\
&+ [P_o \times EF_{gi}][(T - t_o)(GR + RR)] \\
&+ [P_o \times EF_{gf}][(t_n - T)(GR + RR)] \qquad \text{(B.6)}
\end{aligned}
$$

where similar terms have been gathered together.

For allocation purposes, new and modified (growth and replacement) sources are frequently treated differently than existing sources and it is desirable to allocate Q_n between Q_n^e from existing sources and Q_n^{nm} from new and modified sources. As noted in Eq. B.2, existing source activity at t_n is $P_o[1 - RR(t_n - t_o)]$ corresponding to the first term in Eq. B.6. Thus,

$$
\left.
\begin{aligned}
Q_n^e &= \{P_o \times EF_{en}\}[1 - RR(t_n - t_o)] \text{ and} \\
Q_n^{nm} &= \{P_o \times EF_{gi}\}[(T - t_o)(GR + RR)] \\
&\quad + \{P_o \times EF_{gf}\}[(t_n - T)(GR + RR)].
\end{aligned}
\right\} \qquad \text{(B.7)}
$$

The factors in curly brackets ($P_o \times EF_{en}$, $P_o \times EF_{gi}$, and $P_o \times EF_{gf}$) represent the emissions that would occur in the baseyear t_o if the control requirements corresponding to these three emission factors were fully met in that year. It is frequently convenient to rewrite Eq. B.7 in terms of the ratios of the controlled emissions in the year n to the base-year emissions. If EF_{eo} is the base-year emission factor for the source category being considered, the base-year emissions for the category, Q_o, are given by

$$Q_o = P_o \times EF_{eo} \qquad \text{(B.8)}$$

and three ratios may be defined

$R_e = EF_{en}/EF_{eo}$, the ratio, on a per unit of production basis, of emissions from sources emitting at year n retrofit levels to emissions from sources emitting at base-year levels;

$R_i = EF_{gi}/EF_{eo}$, the ratio, on a per unit of production basis, of emissions from new/modified sources built before time T to emissions from similar sources emitting at base-year levels; and

$R_f = EF_{gf}/EF_{eo}$, the ratio, on a per unit of production basis, of emissions from new/modified sources built between T and t_n to emissions from similar sources emitting at base-year levels.

(B.9)

Combining Eqs. B.7, B.8, and B.9 gives

$$\left.\begin{aligned} Q_n^e &= Q_o \times R_e[1 - RR(t_n - t_o)] \text{ and} \\ Q_n^{nm} &= Q_o \times R_i[(T - t_o)(GR + RR)] \\ &\quad + Q_o \times R_f[(t_n - T)(GR + RR)]. \end{aligned}\right\} \qquad (B.10)$$

It should be noted that the emission factors, EF_{ij}, could include the effects of both process changes and control device efficiencies. In general,

$$EF_{ij} = EF_{ij}^{unc} \times (1 - \eta_{ij}/100) \qquad (B.11)$$

where EF_{ij}^{unc} is the uncontrolled emission factor for the source category or process being considered and η_{ij} is the appropriate control efficiency. If no process changes are contemplated as is frequently the case, EF_{ij}^{unc} is the same for all categories ij of source activity and Eq. B.9 can be rewritten:

$$R_e = \frac{EF_{en}}{EF_{eo}} = \frac{EF^{unc}(1 - \eta_{en}/100)}{EF^{unc}(1 - \eta_{eo}/100)} = \frac{(1 - \eta_{en}/100)}{(1 - \eta_{eo}/100)}.$$

Thus, if no process changes occur,

$$\left.\begin{aligned} R_e &= \frac{(1 - \eta_{en}/100)}{(1 - \eta_{eo}/100)}, \\ R_i &= \frac{(1 - \eta_{gi}/100)}{(1 - \eta_{eo}/100)}, \text{ and} \\ R_f &= \frac{(1 - \eta_{gf}/100)}{(1 - \eta_{eo}/100)}, \end{aligned}\right\} \qquad (B.12)$$

where η_{eo}, η_{en}, η_{gi}, and η_{gf}, respectively, are the control efficiencies required on original sources in the base year, existing (original) sources in the projection year n, growth and replacement sources built between t_o and T, and growth and replacement sources built between T and t_n.

APPENDIX C. HATREMS EMISSION FACTORS

This appendix contains HATREMS emission factors for lead. It should be noted that the list does not include each SCC for boilers. Only one SCC per fuel type is listed since all boilers using the same fuel type would use the same emission factor. For example, the lead emission factor for pulverized bituminous coal-fired industrial boilers (SCC 1-02-002-01) would be .00160, the same as the lead emission factor for SCC 1-01-002-01 which applies to all bituminous coal-fired boilers. The same default multiplier, 8.300, and control efficiency mulitplier, 100.00, would also apply to both SCCs if HATREMS values were to be used in the emission calculations.

Table C.1 HATREMS Lead Emission Factors for Point Sources

```
 03/21/79                        HATREMS POINT SOURCE EMISSION FACTOR FILE LISTING
                                        POUNDS EMITTED PER SOURCE UNIT

   SCC                    SCC CATAGORY NAMES                                         SOURCE UNITS NAME
POLL CODE  POLL NAME  EMIS FACTOR  DEFAULT MULT  CTL EFF MULT  POLL FLAG          MULTIPLIER UNITS NAME

1-01-001-01  EXTCOMB BOILER   ELECTRIC GENERATNANTHRACITE COAL  PULVERIZED COAL     TONS BURNED
  A2128      PB            .00160       8.300       100.00          1            PPM PB IN COAL

1-01-002-01  EXTCOMB BOILER   ELECTRIC GENERATNBITUMINOUS COAL  PULV: WET BOTTOM    TONS BURNED
  A2128      PB            .00160       8.300       100.00          1            PPM PB IN COAL

1-01-003-01  EXTCOMB BOILER   ELECTRIC GENERATNLIGNITE          PULVERIZED COAL     TONS BURNED
  A2128      PB            .00160       8.300       100.00          1            PPM PB IN COAL

1-01-004-01  EXTCOMB BOILER   ELECTRIC GENERATNRESIDUAL OIL     GRADE 6 NORMAL FI   1000GALLONS BURNED
  A2128      PB            .00420       1.001       100.00          1            PPM PB IN RESIDUAL OIL

1-01-005-01  EXTCOMB BOILER   ELECTRIC GENERATNDISTILLATE OIL   GRADES 1 _ 2 OIL    1000GALLONS BURNED
  A2128      PB            .00420        .100       100.00          1            PPM PB IN DISTILLATE OIL

1-01-013-02  EXTCOMB BOILER   ELECTRIC GENERTTNLIQUID WASTE     WASTE OIL           1000 GALLONS BURNED
  A2128      PB          40.00000       1.001       100.00          1            PERCENTAGE PB IN OIL

3-01-042-01  INDUSTRIAL PROCESCHEMICAL MFG      LEAD ALKYL ALLOY RECOVERY FURNACE    TONS PRODUCED
  A2128      PB          55.00000       1.000       100.00          1            NONE

3-01-042-02  INDUSTRIAL PROCESCHEMICAL MFG      LEAD ALKYL ALLOY PROCES VENT  ETHY   TONS PRODUCED
  A2128      PB           4.00000       1.000       100.00          1            NONE

3-01-042-03  INDUSTRIAL PROCESCHEMICAL MFG      LEAD ALKYL ALLOY PROCES VENT METHY   TONS PRODUCED
  A2128      PB         150.00000       1.000       100.00          1            NONE

3-01-042-04  INDUSTRIAL PROCESCHEMICAL MFG      LEAD ALKYL ALLOY SLUDGE PITS         TONS PRODUCED
  A2128      PB           1.20000       1.000       100.00          1            NONE

3-01-043-99  INDUSTRIAL PROCESCHEMICAL MFG      LEAD ALKYL ELECTRONOT CLASSIFIED     TONS PRODUCED
  A2128      PB           1.00000       1.000       100.00          1            NONE

3-03-003-01  INDUSTRIAL PROCESPRIMARY METALS    COKE MET BYPRODUCGENERAL             TONS COAL CHARGED
  A2128      PB            .00350       1.000       100.00          1            NONE

3-03-005-01  INDUSTRIAL PROCESPRIMARY METALS    COPPER SMELTER    TOTAL/GENERAL      TONS CONCENTRATED ORE
  A2128      PB           4.00000       1.000       100.00          1            NONE

3-03-005-02  INDUSTRIAL PROCESPRIMARY METALS    COPPER SMELTER    ROASTING           TONS CONCENTRATED ORE
  A2128      PB           2.30000        .300       100.00          1            PERCENTAGE PB IN CONCENTRATE

3-03-005-03  INDUSTRIAL PROCESPRIMARY METALS    COPPER SMELTER    SMELTING           TONS CONCENTRATED ORE
  A2128      PB           1.70000       1.000       100.00          1            NONE

3-03-005-04  INDUSTRIAL PROCESPRIMARY METALS    COPPER SMELTER    CONVERTING         TONS CONCENTRATED ORE
```

Table C.1 (Cont'd)

```
03/21/79                                  HATREMS POINT SOURCE EMISSION FACTOR FILE LISTING
                                                   POUNDS EMITTED PER SOURCE UNIT

   SCC                               SCC CATAGORY NAMES                                          SOURCE UNITS NAME
POLL CODE   POLL NAME   EMIS FACTOR   DEFAULT MULT   CTL EFF MULT   POLL FLAG           MULTIPLIER UNITS NAME

  A2128       PB             2.60000           1.000        100.00            1              NONE

3-03-006-01   INDUSTRIAL  PROCESPRIMARY METALS     FERALLOY OPEN FNC50% FESI            TONS PRODUCED
  A2128       PB              .29000          1.000         100.00            1             NONE

3-03-006-04   INDUSTRIAL  PROCESPRIMARY METALS     FERALLOY OPEN FNCSILICON METAL       TONS PRODUCED
  A2128       PB              .00310          1.000         100.00            1             NONE

3-03-006-05   INDUSTRIAL  PROCESPRIMARY METALS     FERALLOY OPEN FNCSILICOMANGANESE     TONS PRODUCED
  A2128       PB              .57000          1.000         100.00            1             NONE

3-03-007-01   INDUSTRIAL  PROCESPRIMARY METALS     FERALOY SEMCOVFNCFEROMANGANESE       TONS PRODUCED
  A2128       PB              .11000          1.000         100.00            1             NONE

3-03-008-01   INDUSTRIAL  PROCESPRIMARY METALS     IRON PRODUCTION   BLAST FNC-ORECHG   TONS PRODUCED
  A2128       PB              .09100          1.000         100.00            1             NONF

3-03-008-02   INDUSTRIAL  PROCESPRIMARY METALS     IRON PRODUCTION   BLAST FNC-AGLCHG   TONS PRODUCED
  A2128       PB              .03300          1.000         100.00            1             NONE

3-03-008-03   INDUSTRIAL  PROCESPRIMARY METALS     IRON PRODUCTION   SINTERING GENERAL  TONS PRODUCED
  A2128       PB              .01300          1.000         100.00            1             NONE

3-03-009-01   INDUSTRIAL  PROCESPRIMARY METALS     STEEL PRODUCTION OPNHEARTH OXLANCE   TONS PRODUCED
  A2128       PB              .14000          1.000         100.00            1             NONE

3-03-009-02   INDUSTRIAL  PROCESPRIMARY METALS     STEEL PRODUCTION OPNHEARTH NOXLNCE   TONS PRODUCED
  A2128       PB              .07000          1.000         100.00            1             NONF

3-03-009-03   INDUSTRIAL  PROCESPRIMARY METALS     STEEL PRODUCTION BOF-GENERAL         TONS PRODUCED
  A2128       PB              .20000          1.000         100.00            1             NONE

3-03-009-04   INDUSTRIAL  PROCESPRIMARY METALS     STEEL PRODUCTION ELECT ARC W/LANCE   TONS PRODUCED
  A2128       PB              .22000          1.000         100.00            1             NONF

3-03-009-05   INDUSTRIAL  PROCESPRIMARY METALS     STEEL PRODUCTION ELECT ARC NOLANCE   TONS PRODUCED
  A2128       PB              .18000          1.000         100.00            1             NONE

3-03-010-01   INDUSTRIAL  PROCESPRIMARY METALS     LEAD SMELTERS     SINTERING          TONS CONCENTRATED ORE
  A2128       PB           105.00000          1.000         100.00            1             NONE

3-03-010-02   INDUSTRIAL  PROCESPRIMARY METALS     LEAD SMELTERS     BLAST FURNACE      TONS CONCENTRATED ORE
  A2128       PB            35.00000          1.000         100.00            1             NONE

3-03-010-03   INDUSTRIAL  PROCESPRIMARY METALS     LEAD SMELTERS     REVERB FURNACE     TONS CONCENTRATED ORE
```

Table C.1 (Cont'd)

```
03/21/79                                HATREMS POINT SOURCE EMISSION FACTOR FILE LISTING
                                                POUNDS EMITTED PER SOURCE UNIT
   SCC                     SCC CATAGORY NAMES                                                SOURCE UNITS NAME
POLL CODE   POLL NAME  EMIS FACTOR  DEFAULT MULT  CTL EFF MULT  POLL FLAG           MULTIPLIER UNITS NAME

  A2128       PB          2.90000       1.000        100.00         1                NONE

3-03-010-04  INDUSTRIAL  PROCESPRIMARY METALS    LEAD SMELTERS      ORE CRUSHING        TONS OF ORE CRUSHED
  A2128       PB           .13000       1.000        100.00         1                NONE

3-03-030-03  INDUSTRIAL  PROCESPRIMARY METALS    ZINC SMELTING      SINTERING           TONS PROCESSED
  A2128       PB         19.00000       1.000        100.00         1                NONE

3-03-030-04  INDUSTRIAL  PROCESPRIMARY METALS    ZINC SMELTING      HORIZ RETORTS       TONS PROCESSED
  A2128       PB          1.20000       1.000        100.00         1                NONE

3-03-030-05  INDUSTRIAL  PROCESPRIMARY METALS    ZINC SMELTING      VERT RETORTS        TONS PROCESSED
  A2128       PB          2.20000       1.000        100.00         1                NONE

3-04-002-05  INDUSTRIAL  PROCESSECONDARY METALS BRASS/BRONZ MELT REVERB FNC            TONS CHARGE
  A2128       PB          5.00000       1.000        100.00         1                NONE

3-04-002-06  INDUSTRIAL  PROCESSECONDARY METALS BRASS/BRONZ MELT ROTARY FNC            TONS CHARGE
  A2128       PB          4.20000       1.000        100.00         1                NONE

3-04-003-01  INDUSTRIAL  PROCESSECONDARY METALS GRAY IRON          CUPOLA              TONS METAL CHARGE
  A2128       PB           .60000       1.000        100.00         1                NONE

3-04-003-02  INDUSTRIAL  PROCESSECONDARY METALS GRAY IRON          REVERB FNC          TONS METAL CHARGE
  A2128       PB           .07000       1.000        100.00         1                NONE

3-04-003-03  INDUSTRIAL  PROCESSECONDARY METALS GRAY IRON          ELECT INDUCTION     TONS METAL CHARGE
  A2128       PB           .05000       1.000        100.00         1                NONE

3-04-004-01  INDUSTRIAL  PROCESSECONDARY METALS LEAD SMELT SEC     POT FURNACE         TONS METAL CHARGED
  A2128       PB           .18000       1.000        100.00         1                NONE

3-04-004-02  INDUSTRIAL  PROCESSECONDARY METALS LEAD SMELT SEC     REVERB FNC          TONS METAL CHARGED
  A2128       PB         34.60000       1.000        100.00         1                NONE

3-04-004-03  INDUSTRIAL  PROCESSECONDARY METALS LEAD SMELT SEC     BLAST/CUPOLA FNC    TONS METAL CHARGED
  A2128       PB         45.00000       1.000        100.00         1                NONE

3-04-004-08  INDUSTRIAL  PROCESSECONDARY METALS LEAD SMELT SEC     LEAD OXIDE MFG      TONS PROCESSED
  A2128       PB           .44000       1.000        100.00         1                NONE

3-04-005-01  INDUSTRIAL  PROCESSECONDARY METALS LEAD BATTERY       TOTAL-GENERAL       TONS OF BATTERIES PRODUCED
  A2128       PB           .88600       1.000        100.00         1                NONE

3-04-005-02  INDUSTRIAL  PROCESSECONDARY METALS LEAD BATTERY       CASTING FURNACE     TONS OF BATTERIES PRODUCED
```

Table C.1 (Cont'd)

```
03/21/79                                 . MATREMS POINT SOURCE EMISSION FACTOR FILE LISTING
                                               POUNDS EMITTED PER SOURCE UNIT

   SCC                             SCC CATAGORY NAMES                                        SOURCE UNITS NAME
POLL CODE   POLL NAME   EMIS FACTOR  DEFAULT MULT  CTL EFF MULT  POLL FLAG        MULTIPLIER UNITS NAME

  A2128       PB             .04500        1.000       100.00         1              NONE

3-04-005-03  INDUSTRIAL  PROCESSECONDARY METALS LEAD BATTERY      PASTE MIXER         TONS OF BATTERIES PRODUCED
  A2128       PB             .05500        1.000       100.00         1              NONE

3-04-005-04  INDUSTRIAL  PROCESSECONDARY METALS LEAD BATTERY      THREE PROCES OPER   TONS OF BATTERIES PRODUCED
  A2128       PB             .73000        1.000       100.00         1              NONE

3-05-006-01  INDUSTRIAL  PROCESMINERAL  PRODUCTS  CEMENT MFG DRY   KILNS               BARRELS CEMENT PRODUCED
  A2128       PB             .02060        1.000       100.00         1              NONE

3-05-006-02  INDUSTRIAL  PROCESMINERAL  PRODUCTS  CEMENT MFG DRY   DRYERS/GRINDERETC   BARRELS CEMENT PRODUCED
  A2128       PB             .00750        1.000       100.00         1              NONE

3-05-006-03  INDUSTRIAL  PROCESMINERAL  PRODUCTS  CEMENT MFG DRY   KILNS-OIL FIRED     TONS CEMENT PRODUCED
  A2128       PB             .11000        1.000       100.00         1              NONE

3-05-006-04  INDUSTRIAL  PROCESMINERAL  PRODUCTS  CEMENT MFG DRY   KILNS-GAS FIRED     TONS CEMENT PRODUCED
  A2128       PB             .11000        1.000       100.00         1              NONE

3-05-006-05  INDUSTRIAL  PROCESMINERAL  PRODUCTS  CEMENT MFG DRY   KILNS-COAL FIRED    TONS CEMENT PRODUCED
  A2128       PB             .11000        1.000       100.00         1              NONE

3-05-007-01  INDUSTRIAL  PROCESMINERAL  PRODUCTS  CEMENT MFG WET   KILNS               BARRELS CEMENT PRODUCED
  A2128       PB             .01875        1.000       100.00         1              NONE

3-05-007-02  INDUSTRIAL  PROCESMINERAL  PRODUCTS  CEMENT MFG WET   DRYERS/GRINDERETC   BARRELS CEMENT PRODUCED
  A2128       PB             .00375        1.000       100.00         1              NONE

3-05-007-03  INDUSTRIAL  PROCESMINERAL  PRODUCTS  CEMENT MFG WET   KILNS-OIL FIRED     TONS CEMENT PRODUCED
  A2128       PB             .10000        1.000       100.00         1              NONE

3-05-007-04  INDUSTRIAL  PROCESMINERAL  PRODUCTS  CEMENT MFG WET   KILNS GAS FIRED     TONS CEMENT PRODUCED
  A2128       PB             .10000        1.000       100.00         1              NONE

3-05-007-05  INDUSTRIAL  PROCESMINERAL  PRODUCTS  CEMENT MFG WET   KILNS-COAL FIRED    TONS CEMENT PRODUCED
  A2128       PB             .10000        1.000       100.00         1              NONE

3-09-040-01  INDUSTRIAL  PROCESMETAL FABRICATIONMETALLIC COATING LEAD CABLE COATIN   TONS PROCESSED
  A2128       PB             .50000        1.000       100.00         1              NONE

3-60-001-01  INDUSTRIAL  PROCESPRINTING PUBLISH  TYPESETTING      LEAD REMELTING      TONS MELTED
  A2128       PB             .25000        1.000       100.00         1              NONE

5-01-001-01  SOLID WASTE      GOVERNMENT       MUNICIPAL INCIN  MULTIPLE CHAMBER    TONS BURNED
```

Table C.1 (Cont'd)

```
03/21/79
                              HATREMS POINT SOURCE EMISSION FACTOR FILE LISTING
                                         POUNDS EMITTED PER SOURCE UNIT
   SCC
POLL CODE  POLL NAME  EMIS FACTOR  SCC CATAGORY NAMES
                                   DEFAULT MULT  CTL EFF MULT  POLL FLAG          SOURCE UNITS NAME
  A2128       PB          .40000       1.000        100.00         1          MULTIPLIER UNITS NAME
                                                                              NONE
5-01-001-02  SOLID WASTE        GOVERNMENT       MUNICIPAL INCIN  SINGLE CHAMBER
  A2128       PB          .40000       1.000        100.00         1          TONS BURNED
                                                                              NONE
```

Table C.2 HATREMS Lead Emission Factors for Area Sources

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03/22/79                                            HATREMS AREA SOURCE EMISSION FACTOR FILE LISTING
                                                          POUNDS EMITTED PER SOURCE UNIT
ASC             ASC CATAGORY NAME
     POLL CODE  POLL NAME  EMIS FACTOR  DEFAULT MULT        MULTIPLIER UNITS NAME     SOURCE RATE UNITS NAME

01   RESIDENTIAL ANTHRACITE COAL
       A2128      PB         .00001        9.000             PPM IN COAL               TONS
02   RESIDENTIAL BITUMINOUS COAL
       A2128      PB         .00110        9.000             PPM IN COAL               TONS
03   RESIDENTIAL DISTILLATE OIL
       A2128      PB         .00004         .100             PPM IN DISTILLATE OIL     THOUSAND GALLONS
04   RESIDENTIAL RESIDUAL OIL
       A2128      PB         .00004        1.001             PPM IN RESIDUAL OIL       THOUSAND GALLONS
07   COMM-INST ANTHRACITE COAL
       A2128      PB         .00180        9.000             PPM IN COAL               TONS
08   COMM-INST BITUMINOUS COAL
       A2128      PB         .00180        9.000             PPM IN COAL               TONS
09   COMM-INST DISTILLATE OIL
       A2128      PB         .00400         .100             PPM IN DISTILLATE OIL     THOUSAND GALLONS
10   COMM-INST RESIDUAL OIL
       A2128      PB         .00400        1.001             PPM IN RESIDUAL OIL       THOUSAND GALLONS
11   INDUSTRIAL ANTHRACITE COAL
       A2128      PB         .00180        9.000             PPM IN COAL               TONS
14   INDUSTRIAL BITUMINOUS COAL
       A2128      PB         .00180        9.000             PPM IN COAL               TONS
16   INDUSTRIAL DISTILLATE OIL
       A2128      PB         .00400         .100             PPM IN DISTILLATE OIL     THOUSAND GALLONS
17   INDUSTRIAL RESIDUAL OIL
       A2128      PB         .00400        1.001             PPM IN RESIDUAL OIL       THOUSAND GALLONS
21   RESIDENTIAL ON-SITE INCINERATION
       A2128      PB         .40000        1.000             NONE                      TONS
22   INDUSTRIAL ON-SITE INCINERATION
       A2128      PB         .40000        1.000             NONE                      TONS
23   COMM-INST ON-SITE INCINERATION
       A2128      PB         .40000        1.000             NONE                      TONS
39   OFF HIGHWAY GASOLINE VEHICLES
                                                                                       THOUSAND GALLONS
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Table C.2 (Cont'd)

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                              HATREMS AREA SOURCE EMISSION FACTOR FILE LISTING
03/22/79                             POUNDS EMITTED PER SOURC" UNIT
                                                                          SOURCE RATE UNITS NAME
ASC          ASC CATAGORY NAME                                    MULTIPLIER UNITS NAME
    POLL CODE  POLL NAME   EMIS FACTOR   DEFAULT MULT
                                                                  GRAMS PER GALLON OF GASOLINE
      A2128       PB            1.65000        1.700
                                                                          THOUSAND GALLONS
AA  LIGHT DUTY GASOLINE FUEL                                      GRAMS PER GALLON OF GASOLINE
      A2128       PB            1.65000        1.700
                                                                          THOUSAND GALLONS
AB  HEAVY DUTY GASOLINE FUEL                                      GRAMS PER GALLON OF GASOLINE
      A2128       PB            1.65000        1.700
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APPENDIX D

GUIDELINES FOR ECONOMIC IMPACT ANALYSIS FOR LEAD SIP

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GUIDELINES FOR ECONOMIC IMPACT ANALYSIS OF LEAD SIP

INTRODUCTION

This document provides general guidelines for the economic impact analysis of State Implementation Plans (SIP) to achieve the ambient lead standard.

There are several steps in the evaluation of the economic impacts of a lead SIP. They include the following:

- o Design alternative strategies and develop costs;
- o Evaluate cost effectiveness of alternatives;
- o Prepare plant - or industry - specific economic analysis addressing capital availability and price/sales/profitability effects and;
- o Determine distribution effects - e.g., how the costs and impacts are spread among and within various economic sectors.

Each of these steps will be discussed below.

Given the limited number of stationary sources of lead*, it may be possible to evaluate the economic impact on a plant specific basis in many states. However, where resources for a plant specific analysis are unavailable, states may elect to use model plants as a basis for cost estimates. In such situations, it should be estimated to what degree plant specific impacts may differ from the model plant estimates.

DESIGNING ALTERNATIVE STRATEGIES

The states may have the option to control different stationary sources in order to achieve the ambient standard. Or, they may have the option of controlling different emissions within a single stationary source. The stationary sources of principal interest are primary lead smelters, secondary lead smelters, gasoline lead additive manufacturing plants, lead-acid battery manufacturing plants, primary copper smelters, and gray iron foundries.

Using dispersion models, such as CRSTER,[41] the relationship between emissions and air quality can be estimated, and the alternative means of "rolling back" emissions to achieve the air quality standard (the strategies) derived.

Designing these alternative strategies, however, requires more than dispersion models per se. A prerequisite of the dispersion models, preparing a detailed source emissions inventory, is a necessary first step. A subsequent step which is also necessary in strategy design, is identifying the control methods which are technically feasible. The Control Techniques Document[24] is a basic source of such information.

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*This example does not address control of mobile source lead emissions.

PROGRAM COSTS

For every alternative control strategy (achieving the standard) the control costs for each source are estimated using primarily the Control Techniques Document.[24] Other cost references such as the GARD Manual[63] may also prove useful. The cost estimate for a facility includes an incremental investment cost and an annualized cost. In addition, an estimate of incremental administrative costs should be made.

Incremental investment costs reflect incremental costs (for emission reductions beyond the level of any other emission regulation) which occur only once, such as the design, development, purchase, and installation of pollution control systems.

The annualized cost is comprised of three components: 1) direct operating cost, 2) indirect costs, and 3) recovery credit. The first component, direct operating cost, includes operating and maintenance costs such as labor, utilities, and materials needed to operate and maintain the equipment. The indirect costs include additional administrative overhead, property taxes, insurance, and the annualized capital charges for depreciation and interest. The annualized capital charges for depreciation and interest are computed using a capital recovery factor which depends on the life of the equipment and the cost of capital. The annual allocation for administrative overhead, taxes, and insurance is usually estimated as a fixed percentage of the installed capital cost.

In some cases, valuable material is reclaimed from the control device. In these instances the recovery credit accounts for the value of the reclaimed material. The annualized cost is then obtained by adding the direct operating costs to the indirect costs and subtracting any recovery credit.

It is also necessary to estimate the administrative costs associated with the alternative control strategy. The incremental administrative costs reflect increased needs for data gathering, monitoring, enforcement, and management activities resulting from the control program. This is best estimated by the state based on experience in administering existing plans and previous revisions.

COST EFFECTIVENESS

With control strategies designed and program costs estimated, a comparison of costs among strategies, cost-effectivenss, can be made. An evaluation of cost effectiveness is needed to identify the initial least cost solutions. The optimal (minimum cost) program is one where the marginal costs of control for all sources are equal. However, what is initially identified as a least cost strategy may not be least cost when plant specific economic effects are assessed. Furthermore, the least cost strategy may be unacceptable given the associated distribution effects. Consequently, the strategy selection process should give preference to the least costly control strategy (considering plant specific economic effects) which attains and maintains the ambient standard with acceptable distribution effects.

PLANT SPECIFIC ECONOMIC EFFECTS

After the initial least cost solutions are identified, the plant specific economic effects are assessed. The main question asked in a plant specific economic effects assessment is: Will control requirements preclude the existence of this plant? To wit: Is control economically feasible; affordable? In answering this question two related issues should be addressed. The first is the availability of financial capital. The second is the price/sales/profitability of the plant after control.

Capital Availability

An important issue to consider is whether firms have adequate financial resources to make the capital outlays required for emission control. In other words, can they raise the necessary capital? If so, does the allocation of capital to emission control projects restrict the firm's ability to fund other productive investments, thereby imposing significant opportunity losses?

To address these questions one must consider the firm's capital st[illegible]ure and financial resources. Internal sources of capital are equal to af[illegible] profits less dividends, plus depreciaton, less additions to working cap. External sources of capital include debt (borrowing and bond sales), and issues of new stock.

The analysis should compare capital requirements with total resources in each category. For internal resources, the annual capital requirement would be compared with total annual internal resource projections. The impact may be measured in terms of the change in the firm's debt ratio measured as the ratio of long-term debt to long-term debt plus equity. This would indicate the extent to which a firm's debt position would worsen if the firm wished to finance emissions controls while continuing all other planned investment projects.

Even a small change in a firm's debt position could represent a significant impact. The investment community evaluates firms on the basis of their expected earnings, the stability of their earnings, the growth in sales, and the riskiness of the firm in light of its debt repayment burdens in relation to its resources. Firms may try to keep their debt ratios low and reserve debt for applications such as boosting sales or entering new markets. Hence, the opportunity costs of even a small change in a firm's debt position may be considerable.

Price/Sales/Profitability Effects

The second issue addressed in determining economic feasibility is: Will prices, sales, and profits be such that after control the plant's minimum acceptable rate of return is achieved? In addressing this issue considerations include the likelihood and consequences of full control cost absorption versus partial or complete control cost pass back or pass forward. Characterization of the plant's market and industry in terms of demand and supply elasticities will aid in identifying the likelihood and consequences of the various cost shifting scenarios.

For example, full cost pass through with increased prices and no output adjustments would be likely where demand was highly inelastic and there were no competing suppliers. Where the potential for substitution is great (demand highly elastic), cost absorption may be a more likely assumption. Absorbed control costs could lead to plant closure and concomitant unemployment. However, this need not always be the case.

Resource Requirements to Do the Analysis

The plant specific economic effects assessment can be as thorough as the state wants it to be. Remember, not every assessment requires an exhaustive analysis. By merely comparing annualized control cost to a plant's annual revenue, the relative magnitude of the cost and the economic effects may be obviously trivial. Furthermore, some of the basic analyses have already been developed. For example, the Economic Impact Assessment[64] and its support background document[65] may provide a useful information base for the plant specific effects assessment.

DISTRIBUTION EFFECTS

With the initial least cost strategy identified and its plant specific economic effects assessed, the distribution effects are determined. The distribution of control costs, price effects, and employment effects provides the answers to the question of who pays. This information should be developed for effects within an economic sector. For example, what are control costs for battery plants A, B, and C? In addition, the distribution effects information should be developed for comparisons among sectors. For example, what are the battery industry costs compared to those for gray iron foundries and secondary lead smelters?

Effects information need not be limited to control cost, price, and employment. Geographic, income, and productivity effects can also be considered. However, no matter how much information is developed the fact remains that the equity or fairness comparison criteria of alternative strategies are subjective.*

OTHER STRATEGIES

Considering the plant specific effects,, the initial strategy may not be least cost. Or, the distribution effects of the initial strategy may not be acceptable. In such instances, other strategies must then be developed. Plant specific economic effects should be assessed for these other strategies. In addition, the distribution effects of these other strategies should also be determined. As mentioned before, the strategy selection process should give preference to the least costly control strategy (considering plant specific economic effects) which attains and maintains the ambient standard with acceptable distribution effects.

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*The one equity criterion that is generally accepted is the "polluter pays principle".

REFERENCES

1. *Guidelines for Air Quality Maintenance Planning and Analysis, Vol. 1: Designation of Air Quality Maintenance Areas,* U.S. Environmental Protection Agency Report No. EPA-450/4-74-001, Research Triangle Park, N.C. (September 1974).

2. _____, *Vol. 2: Plan Preparation,* U.S. EPA Report No. EPA-450/4-74-002, RTP, N.C. (July 1974).

3. _____, *Vol. 3: Control Strategies,* U.S. EPA Report No. EPA-450/4-74-003, RTP, N.C. (July 1974).

4. _____, *Vol. 4: Land Use and Transportation Considerations,* U.S. EPA Report No. EPA-450/4-74-004, RTP, N.C. (August 1974).

5. _____, *Vol. 5: Case Studies in Plan Development,* U.S. EPA Report No. EPA-450/4-74-006, RTP, N.C. (December 1974).

6. _____, *Vol. 6: Overview of Air Quality Maintenance Area Analysis,* U.S. EPA Report No. EPA-450/4-74-007, RTP, N.C. (September 1974).

7. _____, *Vol. 7: Projecting County Emissions, Second Edition,* U.S. EPA Report No. EPA-450/4-74-008, RTP, N.C. (January 1975).

8. _____, *Vol. 8: Computer-Assisted Area Source Emissions Gridding Procedure,* U.S. EPA Report No. EPA-450/4-74-009, RTP, N.C. (September 1974).

9. _____, *Vol. 9: Evaluating Indirect Sources,* U.S. EPA Report No. EPA-450/4-75-001, RTP, N.C. (January 1975).

10. _____, *Vol. 10 (Revised): Procedures for Evaluating Air Quality Impact of New Stationary Sources,* U.S. EPA Report No. EPA-450/4-77-001, RTP, N.C. (October 1977).

11. _____, *Vol. 11: Air Quality Monitoring and Data Analysis,* U.S. EPA Report No. EPA-450/4-74-012, RTP, N.C. (September 1974).

12. _____, *Vol. 12: Applying Atmospheric Simulation Models to Air Quality Maintenance Areas,* U.S. EPA Report No. EPA-450/4-74-013, RTP, N.C. (September 1974).

13. _____, *Vol. 13: Allocating Projected Emissions to Subcounty Areas,* U.S. EPA Report No. EPA-450/4-74-014, RTP, N.C. (November 1974).

14. _____, *Vol. 14: Allocating Projected Emissions to Subcounty Areas - Apendices A and B,* U.S. EPA Report No. EPA-450/4-74-014a, RTP, N.C. (March 1975).

15. *Accounting for New Source Performance Standards in Projecting and Allocating Emissions - Hypothetical Example,* U.S. EPA Report No. EPA-450/4-74-014b, RTP, N.C. (October 1975).

16. Cirillo, R.R., J.F. Tschanz, A.E. Smith, R.F. Freeman, J.E. Camiaiomi, and V. R [illegible] *Air Quality Analysis Workshop Volume I - Manual*, U.S. EPA Report No. EPA-450/3-75-080a, RTP, N.C. (November 1975).

17. *Supplementary Guidelines for Lead Implementation Plans*, U.S. EPA Report No. EPA-450/2-78-038, RTP, N.C. (August 1978).

18. 40 CFR 51, *Implementation Plans for Lead, National Ambient Air Quality Standard*, 43 FR 46264 (October 5, 1978).

19. *Guidelines for Compiling a Comprehensive Emission Inventory*, U.S. EPA Report No. APTD 1135, RTP, N.C. (March 1973).

20. 40 CFR 50, *National Primary and Secondary Ambient Air Quality Standards for Lead*, 43 FR 46245 (October 5, 1978).

21. *Technical Manual for the Measurement of Fugitive Emissions: Upwind - Downwind Sampling Method for Industrial Fugitive Emissions*, U.S. EPA Report No. EPA-600/2-76-089a, RTP, N.C. (April 1976).

22. *Technical Manual for the Measurement of Fugitive Emissions: Roof Monitor Sampling Method for Industrial Fugitive Emissions*, U.S. EPA Report No. EPA-600/2-76-089b, RTP, N.C. (May 1976).

23. *Technical Manual for the Measurement of Fugitive Emissions: Quasi-Stack Sampling Method for Industrial Fugitive Emissions*, U.S. EPA Report No. EPA-600/2-76-089c, RTP, N.C. (May 1976).

24. *Control Techniques for Lead Air Emissions, 2 vols.*, U.S. EPA Report No. EPA-450/2-77-012, RTP, N.C. (December 1977).

25. Zoller, J.M., G.A. Jutze, and L.A. Elfers, *A Method for Characterization and Quantification of Fugitive Lead Emissions from Secondary Lead Smelters, Ferroalloy Plants, and Gray Iron Foundries*, U.S. EPA Report No. EPA-450/3-78-003, RTP, N.C. (January 1978).

26. *Compilation of Air Pollutant Emission Factors*, 3rd ed. with Supp. 1-8. U.S. EPA Report No. AP-42, RTP, N.C. (May 1978).

27. *AEROS Manual Series Volume II: AEROS User's Manual*, U.S. EPA Report No. EPA-450/2-76-029, RTP, N.C.

28. 40 CFR 51, 53, *Ambient Air Monitoring Reference and Equivalent Methods for Lead*, 43 FR 46272 (October 5, 1978).

29. Maxwell, C.M. and D.W. Nelson, *A Lead Emission Factor for Reentrained Dust from a Paved Roadway*, U.S. EPA Report No. EPA-450/3-78-021, RTP N.C. (April 1978).

30. de Nevers, N. and R. Morris, *Rollback Modeling - Basic and Modified*, paper 73-139 presented at Air Pollution Control ASsoc. Meeting, Chicago (June 24-28, 1973).
Note: This reference has been reproduced as an Appendix G to Reference 17.

31. *Guideline on Air Quality Models*, U.S. EPA Report No. EPA-450/2-78-027, Office of Air Quality Planning and Standards Guideline No. 1.2-080, RTP, N.C. (April 1978).

32. *Standard Industrial Classification Manual*, U.S. Government Printing Office Stock No. 4101-0066, Washington, D.C. (1972).

33. Langford, T.W., *Regional Air Quality Maintenance Planning Employment Projections 1975-2000, Chicago, IL, S.M.S.A.*, unnumbered Illinois Environmental Protection Agency Report (March 1978).

34. Commonwealth Edison Co., personal communication (1978).

35. *Illinois Population Projections (Revised 1976): Summary and by County 1970-2025*, unnumbered State of Illinois Bureau of the Budget Report, Springfield, Ill. (July 1976).

36. Hooper, T.G. and W.A. Marrone, *Input Variable Calculation Sheets for EPA-450/3-76-017*, Volumes a-f, U.S. EPA Report No. EPA-450/3-76-01, RTP, N.C.

37. Hooper, T.G. and W.A. Marrone, *Impact of New Source Performance Standards on 1985 Emissions from Stationary Sources*, U.S. EPA Report No. EPA-450/3-76-017, RTP, N.C. (April 1977).

38. *Memorandum of Understanding between the Department of Transportation and the Environmental Protection Agency Regarding the Integration of Transportation and Air Quality Planning*, Washington, D.C. (June 14, 1978).

39. *Transportation - Air Quality Planning Guidelines*, issued jointly by the U.S. Environmental Protection Agency and the U.S. Department of Transportation, Washington, D.C. (June 1978).

40. *Environmental Protection Agency Appendices to Transportation - Air Quality Planning Guidelines*, (June 1978).

41. *User's Manual for Single-Source (CRSTER) Model*, U.S. EPA Report No. EPA-450/2-77-013, RTP, N.C. (July 1977).

42. Tyler, D.D., *Supplementary Guidelines for Lead Implementation Plans -- Corrections*, memo to U.S. EPA Air Branch Chiefs, Regions I-X (December 21, 1978).

43. *Workbook for Comparison of Air Quality Models*, U.S. EPA Report No. EPA-450/2-78-028a, RTP, N.C. (May 1978).

44. *Workbook for Comparison of Air Quality Models - Appendices*, U.S. EPA Report No. EPA-450/2-78--28b, RTP, N.C. (May 1978).

45. TRW Systems Group, *Air Quality Display Model*, National Technical Information Service No. NTIS PB 189194, Springfield, Va. (November 1969).

46. Clean Air Act, 42 U.S.C. 1857 et seq.

47 *Fugitive Emissions from the Integrated Iron and Steel Industry*, U.S. EPA Report No. EPA 600/2-78-050, RTP, N.C. (March 1978).

48 *Technical Guidance for Control of Industrial Process Fugitive Particulate Emissions*, U.S. EPA Report No. EPA-450/3-77-010, RTP, N.C. (March 1977).

49. King, Jr., *Second Symposium of Fugitive Emissions: Measurement and Control*, (May 1977, Houston, Texas), U.S. EPA Report No. EPA-600/7-77-148, RTP, N.C. (December 1977).

50. 40 CFR 51, *Requirements for Preparation, Adoption, and Submittal of Implementation Plans*, 36 FR 22398 (November 25, 1971 et seq).

51. 38 FR 30626, *State Implementation Plan Transportation Controls*, preamble, (November 6, 1973).

52. *Workshop on Requirements for Nonattainment Area Plans*, revised ed., U.S. EPA Report No. OAQPS 1.2-103, RTP, N.C. (April 1978).

53. Chaput, L.S., *Federal Standards of Performance for New Stationary Sources of Air Pollution - A Summary of Regulations*, "Journal of the Air Pollution Control Assn.," *26*(11):1055 (November 1976).

54. Monarch, M.R., R.R. Cirillo, B.H. Cho, G.A. Concaildi, A.E. Smith, E.P. Levine, and K.L. Brubaker, *Priorities for New Source Performance Standards under the Clean Air Act Amendments of 1977*, U.S. EPA Report No. EPA-450/3-78-019, RTP, N.C. (April 1978).

55. 40 CFR 60, *Standards of Performance for New Stationary Sources*, 43 FR 38872 (August 31, 1978).

56. *Guidelines for Development of Control Strategies in Areas with Fugitive Dust Problems*, U.S. EPA Report No. OAQPS 1.2-071, RTP, N.C. (October 1977).

57. *Control of Reentrained Dust from Paved Roads*, U.S. EPA Report No. EPA-907/9-77-007, RTP, N.C. (August 1977).

58. Wiltsee, Kenneth W., Jr., *Development of the 1975 Area Source Inventory for the State of Illinois*, Illinois Institute for Environmental Quality Document No. 76/30, Springfield, Ill. (December 1976).

59. Smith, A.E., K.L. Brubaker, and D.M. Hediger, *Air Quality Impacts of Alternative Policies for the Review of Major New Stationary Sources in the Chicago-Gary Air Quality Control Region*, draft report prepared for the U.S. EPA, Washington, D.C. (November 17, 1978).

60. Burbaker, K.L., P. Brown, and R.R. Cirillo, *Addendum to the User's Guide for the Climatological Dispersion Model*, U.S. EPA Report No. EPA-450/3-77-015, RTP, N.C. (1977).

61. *Report to the U.S. EPA of the Specialists' Conference on the EPA Modeling Guideline*, unnumbered report of the Specialists' Conference on the EPA Modeling Guideline, Chicago (Feb. 22-24, 1977) prepared under Inter-Agency Agreement No. EPA-IAG-D7-0013.

62. Brier, G.W., *Statistical Questions Relating to the Validation of Air Quality Simulation Models*, U.S. EPA Report No. EPA-650/4-75-010, RTP, N.C. (March 1975).

63. GARD, Inc., *Capital and Operating Costs of Selected Air Pollution Control Systems*, U.S. EPA Report No. EPA-450/3-76-014, RTP, N.C.

64. *Economic Impact Assessment*, unnumbered U.S. EPA Report, Office of Air Quality Planning and Standards, RTP, N.C. (September 1978).

65. *Environmental Impact Statement*, unnumbered U.S. EPA Report, Office of Air Quality Planning and Standards, RTP, N.C. (September 1978).